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THE BRIDGE ACROSS SYDNEY HARBOR, for the construction of which bids are asked, as noted in our issues of Jan. 18 and Feb. 22, will be a combination highway and railway structure. At the point of crossing the harbor is 1,880 ft. wide, and it is required that the bridge shall have a height of 180 ft. above sea level. Builders must submit detailed designs and specifications, and in the event of a bid being accepted a preliminary deposit of $50,000 will be required. If no bid is accepted prizes of $5,000 and $2,500, respectively, will be given for the best two designs. Further information regarding the bridge may be obtained of Mr. Julian Solomans, Agent-General for New South Wales, 9 Victoria St., London, England, where bidders can examine maps of Sydney and South Sydney and a drawing of a section across the harbor.

NEW YORK UNDERGROUND RAPID TRANSIT railway affairs have witnessed two important developments during the past week. On March 2 the Board of Estimate and Apportionment of New York city authorized the issue of $36,500,000 of bonds to pay for the construction of the road. These bonds will be issued from time to time in such amounts as may be necessary. The contractor, Mr. John B. McDonald, has also formally turned his contract over to the Subway Construction Co., of which Mr. August Belmont is President, as noted in our last issue. This company will have its offices in the Ivins Syndicate Building, 15 Park Row, New York city. Proposals for constructing 15 sections of the road are being asked, as noted in our advertising columns this week.

IMPROVEMENTS ON THE METROPOLITAN STREET Railway system in New York city will be carried out during the present year, which will entail an expenditure of $10,000,000, according to a statement made by President Vreeland of that company. Briefly stated, the work will consist in changing the present cable lines of the company to the electric conduit system. Among the lines which will be changed are the Columbus Ave., Lexington Ave. and Broadway cable lines, running north and south, and the 125th St. and 34th St. cross-town lines. Some of the other cross-town lines will have new and heavier rails laid, and two entirely new lines will be built—one running across-town at 145th St., and the other running north and south along the Boulevard, between 130th and 175th Sts. Work will be begun at once on some of these lines.

THE RAMAPO WATER CO. proposes to supply the city of New York with water at $70 per million gallons, under a private contract extending over 40 years. The Merchants' Association of New York, in the interest of citizens of New York, compares this proposed deal with the present cost of water, as taken from the report of Chief Engineer Birdsall, of the Water Department, for the Manhattan and Bronx Boroughs in 1898:

Annual maintenance	$959,337.00
Interest on bonds	2,200,000.00
Total annual cost	$3,159,337.00
Cost per day for 243,000,000 gallons.....	$8,657.00
Cost per million gallons; city ownership.....	35.62
Cost per million gallons; Ramapo contract....	70.00

The Association is spending about $30,000 of its own money to investigate the real needs of the city of New York in the matter of water supply; and though this investigation is still incomplete, enough has been gathered to show conclusively that for $100,000,000 the city can obtain and own what the Ramapo Co. would charge $200,000,000 for in 40 years. The difference is worth fighting for by the taxpayers of New York.

MUNICIPAL OWNERSHIP OF WATER-WORKS at Dubuque, Ia., was voted for on Feb. 28, 3,133 to 459. The works were built in 1871 by the Dubuque Water Co., and will now be bought by the city, it is supposed.——On the same date the people of Oskaloosa, Ia., voted against granting a new franchise to the Oskaloosa Water Co., which has supplied the city since 1880, under a 20-year franchise.

A FRANCHISE COMMISSION for the city of Baltimore is provided for by a bill before the Maryland legislature. It proposes a body to investigate the books and affairs of the franchise companies of the city and to regulate their relations with the city, subject to appeal to the courts. Two members of the commission would be appointed by the governor, the other three being city officers, as follows: The comptroller and president of the second branch of the city council, who are elected by the people; and the register, who is chosen by the council. We are indebted to Mr. H. W. Williams, Fidelity Building, Baltimore, Md., for a copy of the proposed act.

WATER CONSUMPTION AND WASTE IN JERSEY City during the last cold spell rose from 28,600,000 gallons on Feb. 24 (Saturday) to 36,052,000 on Feb. 27 (Tuesday). It fell gradually to 29,028,000 on March 5 (Monday). In our issue of March 1 we commented editorially on the increased waste at Jersey City during cold weather. We are indebted to Mr. C. A. Van Keuren, Chief Engineer of the Board of Street and Water Commissioners, for these figures.

DOMESTIC WATER FILTERS AT PUBLIC EXPENSE appear to have been defeated at Evanston, Ill., after a hard struggle. It seems that the city council voted, 7 to 6, to contract with the Wormser Filter Plate Co., of St. Louis, Mo., to place a filter in the house of each water taker, under an eight-year rental contract. The mayor has since declared the action invalid.

WATER PURIFICATION EXPERIMENTS at Philadelphia are to be started soon, a contract having been awarded to Thos. Parker for small sedimentation basins, filter beds and tanks and a laboratory, at a price of $7,837.

MOVING A WATER-WORKS PLANT from Greensburg, Kan., to Alva, O. T., is reported as being in progress. In 17 days' time, it is said, Mr. E. E. Fitzpatrick, of Wichita, Kan., took up 17,000 ft. of iron pipe. This has been shipped to Alva. The plant was built in 1887-8 by the Greensburg Water Supply & Hydraulic Power Co., at a reported cost of $68,000. Later it was sold under foreclosure to the Kansas National Bank, of Wichita, which in turn (about 1892) sold it to the "city" of Greensburg. This "city" does not appear in the census returns of 1880. When the works were completed in 1888 the population was estimated at 2,750, but the census of 1890 showed only 515 inhabitants.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Northampton Division of the New York, New Haven & Hartford R.R., near Plainville, Conn., on March 1. A passenger train went over the embankment at a washout, resulting in the death of four persons, and the serious injury of seven others.

A MINE EXPLOSION of great severity occurred in the Red Ash Mine, near Fire Creek, W. Va., on March 6. The entrance to the mine was completely wrecked and rescuers are experiencing great difficulty in penetrating into the mine on account of debris. Ten men have been removed so far, all of whom are either dead or dying. The total number entombed in the mine is variously estimated at from 50 to 125. The mine is said to have been free from fire-damp, and the explosion is attributed to dust.

LOCAL TELEPHONE SERVICE IN SWEDEN, says a writer in "Engineering," averages $13.40 per year for each subscriber. For this sum the State will erect a line not exceeding 2 miles in length. Telephone unions were first formed, and the necessary money was raised for a central station and each member paid for his own telephone and its installation. The government then bought up these stations under condition that the annual rate should not exceed the above sum, and special rates as low as $2.88 per year are fixed for a series of years. The fee for conversation, not over 62 miles, is 4 cts.; up to 155 miles, 8 cts.; up to 335 miles, 13½ cts.; for longer distances, 27 cts. These fees are for a 3-minute conversation; one-third extra is charged for each extra minute.

A HIGHWAY TROLLEY SERVICE, to be used for supplying electric power to ordinary motor-vehicles, is being tested in France. The invention is that of M. Lombard-Gerin, who proposes to run upon two parallel wires stretched on poles parallel to the highway a small motor-chariot carrying a long conductor, which passes to a trolley-pole on the vehicle to be operated. This conductor operates the motor on the vehicle, and it is long enough to permit very considerable freedom of motion in this vehicle. In the experiments made a 12% grade was mounted with ease, and the general results were satisfactory enough to encourage further tests. This device is fully illustrated in "Le Genie Civil" for Feb. 10, 1900.

THE SHANTUNG R. R. CO., of China, says an official Berlin publication, was organized in Berlin on June 14, 1899, with $12,852,000 capital. The company is pledged to build and put in operation, within five years and three years, 280 miles of railway between Tsingtau, Weihsien and Isinanfu, in the Province of Shantung. The purpose of the road is to open up the great coal districts in the north of this province; it will be standard gage and graded for double track. The German government reserves the right to acquire possession of the road, at a suitable price, at the end of 60 years. Material is already being shipped; 4,200 tons were delivered in December, and 85,000 tons are contracted for.

HAWAIIAN COMMERCE is reported to be so flourishing that the proposed opening in the reef in front of Pearl Harbor is deemed a necessity. Honolulu dispatches of March 2 say that 17 ships were then in that harbor waiting a chance to get to the wharves. An appropriation of $100,000 was granted to the War Department to improve Pearl Harbor, but army engineers were too busy at home, and recommended that the work be turned over to navy control. But Congress has delayed action, though the navy stands ready to do the work, as the government ships are also anxious to use the new harbor.

NICARAGUA is ready to cede canal territory to the United States for a consideration in money, says Managua accounts. There is friction between Nicaragua and Costa Rica, as the former state is anxious to regain territory ceded to Costa Rica years ago, and thus obtain full control of the watershed south of the canal line. Nicaragua would also like to have the Pacific port of Punta Arenas, now far down in Costa Rican territory. The trouble is that both states desire full and exclusive control of the strip feasible for a canal route, so that they may sell or cede to the United States as best suits their individual interests.

THE CAPE COD CANAL is thus referred to in the report of the Massachusetts Harbor and Land Commissioners, for 1899: The Boston, Cape Cod & New York Canal Co. was chartered by Chapter 448, Acts of 1890, to construct and operate a ship canal between Barnstable Bay and Buzzard's Bay. On June 14, 1899, the canal company petitioned for authority to issue stock and bonds, and the commissioners granted authority to issue $140,000 in stock and $140,000 in bonds, as soon as $200,000 was deposited with the Treasurer of the Commonwealth. This was to provide means for paying the county of Barnstable and the towns of Bourne and Sandwich the sums provided in the act, and cover the cost of surveys and plans. An application to permit the issue of the total $6,000,000 in stock and $6,000,000 in bonds, and to keep this amount intact in the hands of a trust company until the canal was completed, was refused, as the law only authorized issue as the work progressed. The canal company made the deposit of $200,000 on Sept. 28, and filed plans of the proposed construction. The matters at issue are still being discussed by the commissioners.

A CIVIL SERVICE EXAMINATION for a mechanical draftsman will be held on March 12 at the offices of the New York Municipal Civil Service Commission in New York city. The subject on which applicants will be examined are: Writing, arithmetic, technical knowledge and experience.

A SOUTHERN PACIFIC R. R. RELIEF DEPARTMENT was established on March 1, 1900, under the executive charge of Mr. A. F. Hess, with headquarters at San Francisco, Cal. This relief fund is based on voluntary contributions from employes, income or profit from investment of money in the fund, and on $36,000 annually paid into its treasury by the Southern Pacific R. R. Co. Membership is voluntary and without medical examination for the immediate present; though after a reasonable time, membership will depend on age and satisfactory medical examination. After March 1, 1900, applicants for employment must first become members of the Relief Department, before entering the company's service. Payments of definite amounts will be made to contributing employes, who, under the regulations of the fund, are entitled to relief when disabled by accident or sickness; and, in the event of death, the payment will be made to relatives or others specified in the application.

LINDE LIQUID AIR MACHINE AT THE UNIVERSITY OF MICHIGAN.

By Alfred L. Davenport.*

A complete plant for the manufacture of liquid air has recently been added to the stock of scientific apparatus at the University of Michigan, through the munificence of Mr. Charles F. Brush, of Cleveland, O., who is an alumnus of the institution. The machine is after Linde's latest type. A general view of the liquefier and compressor as

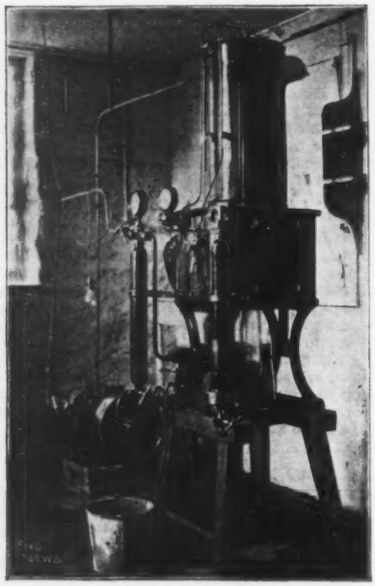

Fig. 1.—The Linde Liquid Air Machine at the Chemical Laboratory of the University of Michigan, Ann Arbor, Mich.

set up in the basement of the Chemical Building, may be had from the accompanying photograph (Fig. 1).

The principle upon which the process of Linde is based is the same as that upon which all other apparatus for the liquefication of air depends for its ultimate success, namely, the compression of the gases and subsequent cooling to the critical temperature by expansion, a cumulative cooling effect being produced by allowing the expanded air and incoming air to pass each other in opposite directions and in close proximity. This feature of the manufacture of liquid air is now too well understood to require further discussion. However, the existing machines differ considerably in the manner in which this is accomplished.

The compressor used in the present plant is an ordinary two-stage air compressor with cooling jackets. Air is delivered from the low pressure cylinder (b in Fig. 2) at 16 atmospheres; it is then cooled by passing through a coil around the cylinder, both coil and cylinder being inclosed in an iron casing through which runs cold water. The air then passes to the high pressure cylinder which raises the pressure to 216 atmospheres; the heat generated in the compression being removed by the second cooling jacket. The low pressure cylinder is about 3 ins. in diameter, and the high pressure cylinder about 1½ ins. The stroke is 2 ins. in each case.

All internal parts of the compressor are lubricated by distilled water which is dropped from the tube (a) and is drawn into the cylinder together with the air. The use of oils is precluded because of the difficulty of their subsequent removal from the air.

From the high pressure cylinder the air is led by a heavy copper pipe (p) of 0.4-in. diameter, to the cylindrical water separator (d), where the greater part of the moisture is removed. A pressure gage (g) is connected with the air pipe at the top of this separator. From this point the dry air is led to the bottom of the carbon dioxide separator (f), which is packed with soda lime. The final purification is effected in a coil of 1-in. iron pipe in the box (e), which contains a freezing mixture of salt and ice. Any moisture remaining in the air up to this point is frozen on the inner walls of the tube. The pure, dry air is now conducted to the top of the liquefier by the pipe (P'), where it enters the inner tube of a long coil composed of three concentric tubes, as shown in the diagram. At the lower end of the coil, the small pin valve (m) allows the air to expand into the middle tube, the pressure being reduced to 16 atmospheres, the difference of pressure at this valve being 200 atmospheres. About one-fifth of this is again expanded through the valve (n) to 1 atmosphere into the outermost tube, while the remainder passes up the middle tube cooling the incoming air and is then led through the pipe (P'') to the high pressure cylinder to be compressed again. Of the portion which is expanded to one atmosphere, a part (about ¼) is liquefied; the rest passes up the outermost tube through the pipe (P''') to the atmosphere, cooling still further in its passage the uncondensed air.

Two small tubes lead from the top of the liquefier; one connected to the middle tube of the coil leads to a pressure gage (H) to show adjustment of expanded air to 16 atmospheres; the other (not shown in the figure) leads from the outermost tube to a small mercury manometer for adjustment of pressure.

The liquid as formed is retained in a heavy Dewar flask (O) underneath the apparatus.

No thorough test of the capacity of the machine has yet been possible, as not all of the parts have arrived from Germany. It has been operated several times, however, without attachment of the carbon dioxide separator, and with very satisfactory results. The liquid obtained in this way is milky in appearance due to carbon dioxide snow. It begins to flow in 30 minutes after starting. Considerable quantities have been made and used in demonstrations before classes at the University.

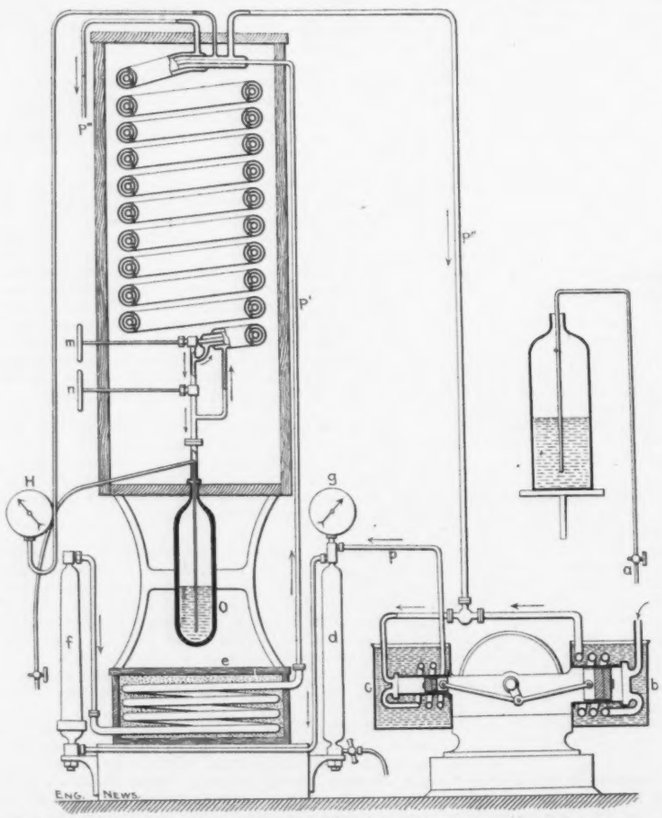

FIG. 2.—DIAGRAM SHOWING OPERATION OF LIQUID AIR MACHINE.

Power is supplied to the compressor by a 5-HP. electric motor. Only 3.5 HP. are, however, required by the compressor, and the liquid is produced at the rate of about 1 quart per hour.

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NOTES ON ELECTRIC TRACTION UNDER STEAM RAILWAY CONDITIONS.*

By Edward C. Boynton, M. Am. Inst. Elec. E.†

On many of the large steam railway systems in the United States there are certain sections which present the most favorable conditions for the substitution of electricity for steam as a motive power. The electric street railroads quickly took advantage of these conditions, and by building lines more or less parallel to the steam roads, soon acquired a large share of the local passenger traffic. The fault with the steam road was not that the motive power was steam, but the fare was too high and the train service too infrequent. The whole question of the substitution of electricity for steam hinges upon that one point.

In order to provide satisfactory transportation facilities, the steam road must double or quadruple the number of its trains, and reduce the fare to at most 1 ct. per mile. When there is sufficient density of population, this will surely cause a large increase in the number of passengers carried. This increase is due principally to the fact that many people who could seldom afford the expense of traveling would then make frequent trips. It is very doubtful whether the greater number of steam trains can be operated at a sufficient profit with the low fare. Here, then, comes in the change in motive power, with the sole purpose of decreasing the operating expense.

I wish to call attention to two classes of local passenger traffic which should be considered as distinct from each other. The suburban traffic of a large city is well understood, and its characteristics are usually such as would make the change from steam to electricity profitable. The low fare will induce a part of the population to make their homes in the suburbs, and thus increase the travel. But where there are competing trolley lines, the steam road, which we will suppose has electric motive power, needs one more facility than those mentioned, and that is, high speed. Without that, there would be little advantage over the competing lines. It has been proved by experience that the speed must be at least as great as an average steam train, and there is no doubt that if the speed be made as high as the fastest steam express train, the popularity of the line would increase.

The other class of traffic referred to is that existing between cities and towns in close proximity. Let us assume a case as an example. In a certain densely populated manufacturing state, there is a city larger than any other within 50 miles radius. Within that radius are several towns and small cities not over 20 to 30 miles from the larger city. These are connected by the steam road, which maintains what is considered a reasonable train service, and one that is as frequent as the traffic seems to demand, at the rate of fare charged, which is from 2 to 2½ cts. per mile. The trains are quite heavy, nearly always fully loaded, and are run from two to three hours apart. Together with its freight traffic, such a road pays well, judged from the steam road's standpoint. Suppose that electricity be substituted for steam in that section, and a train service consisting of two, or three car trains running every half hour from each end, with a maximum speed of 50 to 60 miles per hour, and the fare reduced to 1 ct. per mile. There is no doubt in the minds of those who have watched the development of such cases, that the increase in traffic and low operating expenses would result in a far greater profit than was ever earned by that section of the road. It is well known that such conditions exist on our steam railroads in many localities.

The Question of Equipment.

The questions, how much will it cost to equip a given

*Condensed from a paper read before the American Institute of Electrical Engineers.

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service to be operated by electricity?—and how much will it cost to operate it? are frequently asked. The electrical engineer is now in a position to answer both these questions with great accuracy. The experimental stage has passed, and sufficient data is at hand to give all the information needed. It must be realized that the operation of a steam railway by electric power introduces many conditions which do not exist in the transportation problem within a great city, such as are operated by the elevated or surface street railroads. There are no restrictions on speed or weight of trains. Rapid acceleration is not of so much importance, for the stops are much further apart. The trains must be operated under steam rules absolutely, and the whole equipment must comply with the laws relating to steam railway trains. The railway company contemplating the equipment of a part of its system with electric motive power has the choice of several methods, which should be closely studied to determine which is best suited for the service it is proposed to operate.

These methods are:

(1) The purchase of electric locomotives of sufficient power and weight to haul its standard passenger coaches. (2) The equipment of a number of its standard coaches as motor cars. (3) The purchase or building of a sufficient number of special light passenger coaches, some of which are equipped as motor cars, and the withdrawal of its standard coaches entirely from this service. (4) Shall freight be hauled by electricity or steam?

The use of electric locomotives for the purpose under consideration depends upon several conditions. If the travel is heavy, that is, 2,000,000 passengers per year and upward, the service frequent, the speed high, requiring an average train of four cars, and, as may be the case, the same coaches must go much further than the electric service extends, hauled by steam, it is advisable to use the electric locomotives hauling standard coaches. Their principal advantage lies in their ability to perform the work of a steam locomotive in every respect, and this is frequently a strong point in their favor with the railway managers. They are thus able to accommodate themselves to congested traffic, which usually occurs on holidays and possibly at certain times every day, by simply increasing the number of coaches hauled, as is the practice with steam locomotives. Such locomotives should weigh from 100,000 to 150,000 lbs., should have eight wheels and four motors, so that the total weight is available for traction. They must be provided with sufficient power to haul at least double the average train without overheating. They must not only be able to perform the work of a steam locomotive in the same service, but should do it at a faster schedule speed. The rapid acceleration of a train hauled by such a locomotive enables it to perform the above duty without any increase in the maximum speed. In switching cars, the ease and rapidity with which the electric motor can be handled is a great advantage

It is necessary to equip these electric locomotives with the best automatic air brake system obtainable, for several reasons. They must operate the existing brake system on the coaches as well as the steam locomotive does. The law requires automatic brakes and a whistle. An independent motor compressor with a large main reservoir is therefore almost imperative. The fact that an electric locomotive requires but one set of controlling and air braking apparatus is a distinct advantage over other methods of employing electric motive power. This is evident, not only in the first cost, but in the fewer parts to be cared for.

The cost of repairs on an electric locomotive should be exceedingly low, possibly 10% of that required by a steam locomotive, on account of the fewer moving parts and the entire absence of the boiler and its necessary equipment.

The second method of applying electric motive power to an existing steam railway—the equipment of standard coaches as motor cars—will appeal to all steam railway managers as the cheapest and most convenient way to make the change. This method has strong arguments in its favor. The locomotive carries its own paying load, and during the hours of light travel can be run light, without hauling other coaches. A standard coach equipped with two motor trucks and four motors will haul nearly as many coaches as the locomotive above mentioned and will weigh 100,000 lbs. It will easily handle five coaches, making a six car train weighing loaded 450,000 lbs. I believe that the power consumed per passenger carried in a train hauled by an electric locomotive will be less than if all the cars were motor cars, whether run singly or in one train.

The total weight of a 60-ft. standard coach equipped as a motor car with two motors will be about 80,000 lbs., without passengers, of which 55,000 lbs. is on the drivers or motor truck. The speed of such a motor car running light, if geared sufficiently high, is probably only limited by its weight and the quality of its track and roadbed. With a stone-ballasted track, 100-lb. steel rails, few curves, and those of long radius, a heavy car with the best steel-tired wheels should run 100 miles per hour at full speed without difficulty.

I have mentioned a four-motor car consisting of a 60-ft. car body weighing 100,000 lbs. complete. This represents about 800 HP. nominal rating of the motors at 650 volts direct current, and this is the maximum horse power that can be placed under a standard coach, on trucks and wheels which do not necessitate any other changes in the existing standards of steam practice. The motors are capable of exerting double that power for a short time. The total cost of converting a standard coach into a motor-car with two motors is about $3,800.

The third method of using electric traction in steam service, that of the use of light motor cars and trailers, built for the purpose, has some advantages. The former coaches can be used elsewhere on the system as are the locomotives. The smaller, lighter cars are cheaper to construct, the wear on the track is less, and there is considerable economy in power. It has been proposed, and no doubt will come, that such cars will run through the principal street of a city, on the existing street car track, before starting on their trip over the steam track. This would necessitate either a trolley wire over the steam track, instead of a power rail, or both collecting shoes and trolley pole on the car. There is no question but that this may prove a great advantage in time. On the other hand, the cars must be used exclusively on the line equipped with electric power. At speeds of 50 to 60 miles per hour, which must be made in order to compete successfully with the existing parallel trolley lines, the cost of maintenance and repairs due to the excessive vibration will undoubtedly be greater than that with standard coaches.

The economy in power due to the reduction in dead weight hauled is of considerable importance, not only on account of the smaller amount used, but the line conductors can be lighter, greatly reducing their cost, or the system can be extended to longer distances at no more expense for transmitting the power.

In the future there may be a decided tendency to reduce the weight of electric trains. In other words, it will be an attempt to handle a constantly increasing traffic with a lighter equipment in order to haul less dead weight per passenger. The engineer who proposes to introduce such changes must move with the greatest care in order not to save the weight at the expense of strength. It should never be forgotten that the maximum load is "no standing room," that the strains on a car and its trucks running at 60 miles per hour over a steam track which may be made of 70-lb. rails with joints none too good, are not to be compared with such as are met with in a city street at low speed.

An interesting problem in connection with a similar equipment has arisen within the last few years, and the time is rapidly approaching when it must be solved. It relates to the difference between the wheels of street cars and the steam railroad coaches. Though both use the standard gage of 4 ft. 8½ ins., the average street car wheel has a tread 2½ ins. wide and a flange ¾-in. deep, while the Master Car Builders' standard requires a tread 4 ins. wide and a flange 1⅛ ins. deep. The problem is a serious one, for it intimately concerns the safety of the train. The steam railroad people, after 50 years' experience, have settled upon the above standard, and the electrical engineer who chooses to ignore their experience in this, and in many other cases, runs a risk. There should be no doubt that it is unsafe to run the small street car wheels at high speeds over steam railroad tracks, with their present form of frogs and switches; and it is, in fact, impossible to run them on steel rails weighing 90 to 100 lbs. per yd. on account of the wide spaces in the frogs. The question may be asked: "Is it not safe to run such narrow wheels on the steam track if the latter is kept carefully to gage, and proper frogs for these wheels are substituted for the existing ones?" If this is done steam trains can no longer run on the road, and, as it is necessary in order to round a curve at high speeds with safety, to spread the gage from ¼-in. to ½-in., the danger is greatly increased. On the other hand, the Master Car Builders' wheels cannot run on the existing street car tracks in our cities. The flange is too deep for the frogs, the size of the groove on the inside of the straight rail is larger than the city authorities would sanction, and the outside portion of the tread would in many cases run on the pavement and crush it down to a level with the top of the rail. The only solution of the problem seems to be a compromise wheel with about 3-in. tread and 1-in. flange. Whether or not this is safe, only time can tell.

The fourth question, that of hauling freight by electric power, should, of course, be decided upon at the time of installation, as it may cause considerable difference in the plans for power stations and line transmission. As the question can only refer to local freight along the line electrically equipped, it is of doubtful importance as applied to the conditions under discussion. If the freight traffic on such lines be sufficiently heavy to necessitate the use of a locomotive for several hours daily during the hours between midnight and morning when there are few if any electric passenger trains in service, it is economy to use an electric locomotive, for it costs but little more to run the power station, if it has been shut down, and the total expense would be somewhat less than that of a steam locomotive. The whole question of transportation of freight by electric power is one which concerns the future more than the present. When the time arrives that long distances are electrically equipped on our steam railways, then it becomes far more important.

Power Transmission.

Feeders.—The transmission of electric power forms the most important part of the problem of the electrical equipment of a steam road. At the present day our railway motors all require the direct current, and we are therefore limited to its employment in the working conductor. By increasing its voltage from that usually employed to 700 volts, a considerable advantage is at once gained, and without additional expense in motors or generators. Experience has shown that the economical radius of operation of a power station generating such a current and delivered to the line without feeders is from 10 to 12 miles. This refers to a heavy train service with a fairly frequent schedule, and an average load of 500 amperes on each radial line of single track.

By the line or working positive conductor is here meant a steel rail of 90 to 100 lbs. per yd., well bonded, and equal in conductivity to about 1,200,000 cm. of copper. The statement, "without feeders," may be wondered at, and a few words of explanation will be necessary.

It should be remembered that the conditions are very different from a street or elevated road. There may be only two, or at most three trains running. The greatest fall in potential occurs when a train is leaving the further end of the line, and this may be somewhat less than ¾ of a volt per ampere at that point, while the average efficiency of the line is over 75%. Again, even if the loss in the line becomes greater through an attempt to increase the number of trains, or to extend the line, the question of feeders depends almost wholly on the cost of fuel. If the interest on the cost of feeders is greater than the saving in fuel consumption effected by their use, and a satisfactory train schedule can be maintained without them, it cannot be in the interest of economical operation to provide them. It has been said that such feeders in connection with the so-called booster used to overcome the drop in the feeders, and a consequent decrease in their weight, are the most economical. Such an arrangement is undoubtedly cheaper as regards first cost, but I have seen no data showing the cost of maintenance and depreciation of these additional machines, as compared with the cost of a feeder of sufficient weight to perform the work without a booster, and on which there is practically no depreciation. Whichever method is followed, the cost of feeders for such a road will reach many thousands of dollars, and railway managers will make the most rigid investigation of traffic conditions, present and prospective, before deciding upon such an outlay.

The above statement should make intelligible the reason why 10 or 12 miles is considered the maximum radius of operation of a station delivering 700 volts direct current. It is hardly necessary to add that a larger system extending over greater distances should be supplied by multiphase generators, and a high tension transmission line combined with the usual rotary converters, located at suitable points on the system. In the absence of a practicable alternating current railway motor, the above system is the only one—there is no choice.

In regard to the most economical material to use as feeders, the extremely variable prices of both copper and steel renders it difficult at present to come to a satisfactory decision, but with both metals at what we may call their normal values, steel is cheaper and more satisfactory. The author believes a proper feeder for 700 volts direct current should be made of flat steel bars about 1 in. × 5 ins. section, two of which are placed side by side, bolted or riveted together with alternated joints and supported on edge in the slotted tops of small posts set in the ground at the side of the roadbed, not over 2 ft. high and boxed in. At grade-crossings the break in these feeders must be bridged by either an underground or overhead connection. In yards and stations where there is a multiplicity of tracks, it will be frequently necessary to carry them overhead for considerable distances. Copper is of course used in such cases.

The Working Conductor.—In considering a train service consisting of heavy trains running at the speeds mentioned, the trolley wire as a working conductor will probably not come into general use, although it is used for such a service to-day. The cost of construction, maintenance and depreciation is greater than that of a third rail. It has few advantages, and many disadvantages for such a service. It is now generally conceded that an insulated rail placed close to the track answers all requirements, and the author's experience shows that it is satisfactory. It is difficult to understand, however, why the common form of T-rail is so generally used for this purpose unless it is due to a desire to save money by using up old rails. A more inconvenient cross-section for thorough and efficient bonding could hardly be selected. It will be admitted by all that this conductor should be so bonded that when worked at its full capacity there should be no greater loss at the joints than elsewhere. There are a number of standard commercial forms of rolled steel which are no more expensive than T-rails that are well suited for this purpose. A form that will permit the use of one or more thin copper plates

of ample area of contact held at the joints between a steel splice plate and the conductor by heavy pressure obtained by the use of a sufficient number of bolts, is an inexpensive and satisfactory bond. The rule that the bond shall be equal in carrying capacity to the conductor, and the area of contact equal to or greater than the cross section of the conductor is a safe one to follow.

One question which has been studied with care is of great importance in this latitude, and that is the effect of ice on the contact surface, and how to get rid of it. Many experiments have been tried, and few can be said to have been successful. A further possible advantage of the use of some other form of rolled steel might result in the complete elimination of this trouble. I refer to the collecting shoes having a side or under running contact. This would allow the partial roofing over the conductor by wood, which would thoroughly protect it from the weather.

Ordinary snow storms and even blizzards do not interrupt the service. I have seen a storm which tied up nearly every wheel in a nearby state, but the electric service was the last to succumb, and even then it was not on account of the conductor rail, or too much snow on the roadbed, but from a train running off an ice-choked frog. It has been demonstrated that motor coaches equipped with proper steel brushes for a third-rail and snow plows, can go through as much snow as an ordinary passenger locomotive. Their great advantage lies in the fact that they can run through deep snow slowly, due to the enormous torque of the series motors and the absence of reciprocating parts. But when the temperature of a conductor rail is below freezing point, and it begins to rain, as is not infrequently the case, a coating of ice forms on the contact surface which closely resembles enamel. No mechanical method has been found to completely remove this.

As to chemical methods, certain roads can and do use salt or brine. It is not considered advisable to salt the roadbed of such a road as is under discussion owing to the danger of leakage should the track become flooded with water. When applied at the right time, an oil which does not solidify at a low temperature is sometimes successful, but the difficulty of applying it to the whole road at the proper time can be appreciated.

Insulation.—The question of insulating the positive rail of a 700-volt grounded circuit has in actual practice been developed to such an extent that the results obtained are remarkable, to say the least. If such methods as are now in use had been proposed ten years ago, they would have been regarded as impracticable.

For years it was the custom to consider the ground a conductor of electricity. It was of course realized that the surface rails must be bonded in some way, but the ground was considered to be a great aid to the rails in returning the current. I do not propose to deny that this is true in a crowded city where there are thousands of tons of iron pipes buried but a short distance beneath the rails, but can we call this a ground return? My experience shows that the roadbed of a steam road consisting of sand, gravel or rock ballast, when dry, is a good insulator, and when wet there is but little difference. A rock-ballasted track in particular needs no insulation whatever except the wooden ties.

I am aware that such a statement may be regarded with doubt, but perhaps it can be made clearer if we take all things into consideration. The road runs through an open country, the soil is of the average composition, some of it wet, but most of it dry. If one stands on a wet spot and places his body in circuit from positive to ground he receives a shock, perhaps of maximum voltage. This would apparently show the ground to be a conductor, but a little thought will prove that it conducted a few milli-amperes only. If one stands in dry earth or on a tie, he feels no shock. But the one test that proves the insulation of such a line is the leakage test. From tests made every night, for over a year, the leakage averages ½ ampere per mile in dry weather to 1¼ amperes in wet weather, and I am convinced that nearly all of this is in the underground work necessary at grade crossings and switch points. The above refers to a rail insulated upon creosoted wood blocks attached to the ties. A complete covering of snow has little or no effect on the leakage. The form of the positive rail may influence the leakage somewhat. For example, the inverted V form acts as a roof to shed water and keeps the contact surface between the block and rail dry. But there are in use several miles of ordinary T-rail as a positive conductor, laid on blocks of wood 1½ ins. thick attached to the ties, not creosoted, but dipped in an insulating compound. No leakage is noticeable here. We can easily understand that if any appreciable amount of the current in amperes should leak through these blocks, whether prepared or not, they would burn up. The writer, therefore, believes that such insulation of the positive rail for the current and voltage under discussion is ample, and much expense can be saved by steam roads by its use.

Track Bonding.—One of the most necessary and at the same time expensive parts of the work in changing existing steam roads into an electric line, is the bonding of the service rails. The author believes he has done some of the heaviest bonding in the country, and is of the opinion that there is no satisfactory method of bonding a T-rail at present. When such bonding costs $2 per joint, it becomes a very serious matter. Bonding around the angle plate with the bonds about 2 ft. long, is out of the question for the cost of copper would be too great, and it would be exposed. Riveting the lugs on the bonds through the web of the rail is not good practice, because to secure sufficient area of contact four holes would have to be drilled in the ends of each rail, which so weakens it as to render it unsafe. The shortest possible bonds should be used under the base of the rail. It requires 4 1-in. holes in the base of each rail, and we can easily see how unsatisfactory and expensive this is, with four bonds of 300,000 cm. area for each joint of 100-lb. steel. In nearly all rail bonds the principal resistance is the contacts. It is a simple matter to use sufficient copper, but to secure a proper contact is a difficult problem. The bonds must have the utmost flexibility to withstand the vertical motion of the rail ends, and even then many of them will gradually break off strand by strand. What is urgently needed at the present day is a cheap and efficient bond for a T-rail. Such a bond, to be satisfactory, must show no greater fall in potential than an equal length of the rail itself, when the maximum current is flowing through the joint. On account of the fact that the ground is practically of no value in augmenting the conductivity of the return circuit, the entire circuit must be regarded as metallic, and the ground should not enter into any calculations.

Power Stations.—The writer does not propose to enter into the subject of the design and arrangement of machinery in a power station for a steam road as there are no engineering features which differ from those encountered in such a station intended for a large street railway. An abundance of water and cheap fuel are of course important points. Such power stations can be built for from $80 to $90 per K-W., exclusive of the land.

A few words about the amount of power required may be of interest. An important figure is the amount of power delivered at the switchboard per train mile. It eliminates all losses due to resistance of circuit, and current used for air compressors, electric lights and heaters. This figure will vary from four to six kilo-watt hours per train mile, reaching its maximum in December and January, due to the longer hours of lighting the cars, the constant use of electric heaters, and the frequent running through snow.

The question of heating a standard coach by electricity is one that should be thoroughly understood. Street car heating is totally different. The public demands the same temperature as is furnished by steam, which is 68° or 70° F. It makes but little difference what heater is used, provided there are enough of them. One may radiate its heat faster than another, and so raise the temperature of the car more rapidly, but it will require, in any case, from 12 to 15 kilo-watts of energy for each coach. An ordinary train consisting of a motor car and two coaches, weighing 200,000 lbs., will require, at a speed of 35 to 40 miles per hour on a level track, about 125 kilo-watts, or about 166 HP., of which the car alone would consume 75 K-W., if running light. The motor will consume an average energy of four to five kilo-watt hours per train mile, or 40 to 50 watt hours per ton mile. Power can be produced with condensing engines and fuel at about $2.30 per ton, for about 0.8 ct. per K-W. hour.

Cost of Operation.—It is most desirable in operating a heavy electric service over a railway on which steam trains are also operated, to arrive at a satisfactory conclusion as to the comparative cost of operating each type of train per mile. It may be said that the cost of operating a steam passenger train has been estimated all the way from 30 cts. to $1.00 per mile, depending upon the length of the train and other conditions which are seldom alike in the different localities. The author cannot go into this subject in detail, but will give a few points of difference between the two services upon which an approximate estimate can be based. A fair average cost of running a steam locomotive, including fuel, when coal is about $2.30 per ton; water, wages, repairs, etc., is 22 cts. per mile. The average cost of repairs to coaches may be taken at 1 ct. per mile each. The wages of train crew, consisting of a conductor, baggage master and one brakeman, will average 5 cts. per mile, making a total of 30 cts. This figure is intended to represent the lowest possible cost of operating a train of only three cars by steam with the understanding that it is kept almost constantly moving for about nine hours, and covering from 150 to 200 miles. It is well known that a train making but a few miles per day cannot be run at a profit, either by steam or electricity, due to the fact that cost of wages per mile increases rapidly, as the crew has to be paid the same in either case. A great advantage of the electric service may be mentioned here. The above service is all that can be required of one crew and one locomotive, but the motor car can easily make 300 to 400 miles in 18 hours, and as the daily service is in operation at least that long, one motor car does the work of two locomotives. In the operation of a similar three-car train, in which one car is a motor car, we will assume the same crew with the addition of a motorman and omit the locomotive. The cost per mile in wages will then become 6½ cts., that of repairs to cars the same as before, 1 ct., maintenance of motors, ½ ct., and cost of power delivered to train 6 cts., making the total cost per train mile 14 cts. for the electric service.

A NEW FORM OF ROLL CRUSHER FOR ROCK AND ORE CRUSHING.

The accompanying illustrations show the design and construction of a new form of roll crusher which it is thought will be an improvement in several respects over the ordinary construction of crushing machinery of this type. In designing parallel roll crushers the mechanical engineer is confronted with a rather difficult problem in the important task of mounting the rolls so that they are elastic enough to pass uncrushable fragments without endangering the machinery from shocks and at the same time of keeping them rigid enough not to pass uncrushed any considerable

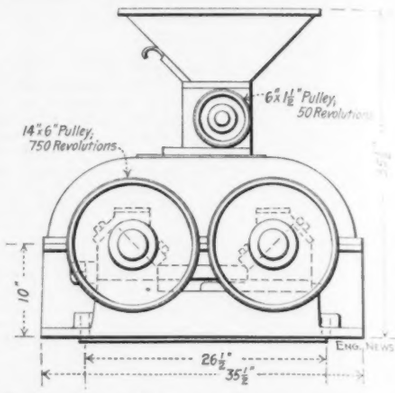

Fig. 1.—Side Elevation of Centrifugal Roll Crusher, Showing Driving Arrangement. Sturtevant Mill Co., Boston, Mass., Builders.

amount of the material which should be crushed, but which may be somewhat harder than the ordinary. Under the very best conditions the shocks which the rolls transmit to their axle bearings are quite severe, and they are usually provided for not only by great strength in these parts but by spring mountings to absorb the more severe blows. The spring mounting is a characteristic and essential feature of nearly all successful roll crushers, and it is in its method of doing away with this mounting that the roll crusher which we illustrate here is chiefly notable.

Fig. 1 is a side view of the new crusher, from which it will be seen that it does not differ materially in appearance from other forms except in the fact that the axle bearings for the rolls are mounted rigidly without springs. Fig. 2 is a longitudinal section of one of the rolls attached to the axle, and it will be seen at once that the construction is unusual. Mounted on the shaft are two flanged hub castings between which is a ring

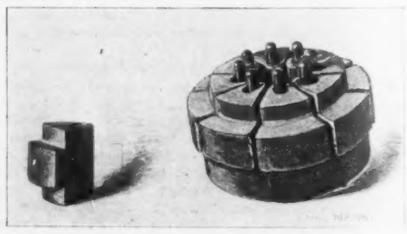

Fig. 4.—View of Stamp Roll, Showing Arrangement and Appearance of Segment Castings.

of segments W, having oblong slots S, through which pass pins P, the ends of which are carried by the hub castings. The segments being mounted loose on their pins and with a free play in and out radially from the axle, they "set out" from centrifugal force when the shaft revolves. Encircling the ring of segments is the loose tire T. When the roll is stationary this tire hangs loose, and it still remains loose as the shaft begins to revolve, until the speed is great enough to throw the segments by centrifugal force against its inner periphery, when the tire commences to revolve with the segments. This tire constitutes the crushing face of

the roll. The flanged hubs prevent the segment castings from exerting an expanding force on the tire, but give them enough play to hold the tire in position against the pressure of the material being crushed. Should a fragment of iron or some other uncrushable material get between the rolls, however, it simply forces back the tire and weights enough to give it passage without transmitting any shock to the roll axles. The action may be illustrated in a crude manner by a weight swung around by means of a cord; the weight may be pressed back but no push is transmitted to the hand which grasps the other end of the cord.

The preceding description explains the principle of the new roll crusher and its construction quite clearly. Some further details regarding its efficiency and the calculation of the forces developed have been obtained by us from the manufacturers, who write as follows:

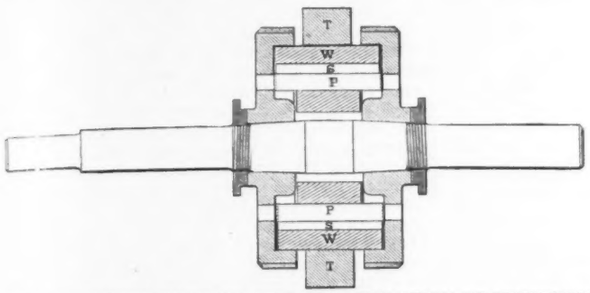

FIG. 2.—SECTION SHOWING ROLL CONSTRUCTION OF CENTRIFUGAL ROLL CRUSHER.

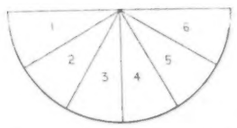

Fig. 3.—Diagram Explaining Method of Calculating Centrifugal Crushing Force of Crusher Roll.

The computation of the centrifugal force exerted by these rolls at different velocities is a simple matter. It is calculated for each size by the well-known formula,

$$F = 1.2276\ w\ r\ n^2,$$

in which w equals the weight, n equals the number of revolutions per second, and r equals the radius of the center of gravity in feet. A large portion of the crushing power of centrifugal rolls is, however, given by the inertia of the parts. The weights are held out by centrifugal force, and any effort to push them in towards the shaft is resisted by centrifugal force, and also by the inertia of the weights. This enormously increases the crushing effect as the rotative speed is increased. This point may perhaps be illustrated by the movements of a carriage wheel meeting a stone on the highway. At slow speeds the carriage passes without serious jolt or injury, but at some increased velocity the carriage will be overturned, or damaged, or the rock will be pulverized.

We figure the centrifugal force utilized in a pair of 24-in. centrifugal rolls, having twelve weights of 100 lbs. each, and a 5-in. tire weighing 400 lbs., as follows: The diagram, Fig. 3, represents the six weights utilized in constant crushing. A close approximation of their resultant forces actually utilized is one-third at 500 revolutions. Then by the formula, the crushing power at the point of application would be about 12,000 lbs. To this must be added the inertia of the six 100-lb. weights plus the 400-lb. tire, or, in all, 1,000 lbs., or rather the inertia thereof. The sudden seizing of the feed at high speeds also contributes a blow to the efficiency of centrifugal rolls, so that altogether they have a practical efficiency not easily measured by figures, but much in excess of what the formula would indicate as probable.

The shock to the material in fast-running rolls contributes greatly to the efficiency of these rolls, which themselves run easier at high speeds because the material pulverizes at once, and the weights are not so much pushed back when running fast. In fact, when properly adjusted to the work, the movement of the weights is a negligible quantity. It will be noticed that the weights do not exert expanding pressures on the tire beyond what is necessary for driving purposes. This is an easy fit. The strong side flanges and stout pins are the safety devices that make it impossible, in case of breakage, for the weights to be thrown out, and escape.

It may be interesting to note that for many purposes the tire is unnecessary. Fig. 4 is a view of our stamp roll. This is the same roll, except it has no tire, and is not capable of doing quite as fine work as the tire roll. It will be seen that only one weight acts at a time in each roll of this kind, but the pressures are ample. We call this a centrifugal stamp roll, because the weights come together at a high speed on the material between them and shatter it like a stamp. It runs almost as quietly as a dynamo, the shocks balancing each other, and, although, owing to its slightly broken face, it cannot do quite as fine work as the continuous tire roll, it has the advantage that it will take in a slightly coarser feed.

We do not feel competent to give a formula for computing the part taken by inertia, and the percussive action of bodies moving at high speeds towards each other, and upon the body caught between them, but in practice this action is found to be of much importance. The centrifugal stamp rolls are so called because this stamp feature is so evident in their work. It is impossible to see them in operation without the suggestion of two hammers coming together on a substance. The rocks fly to pieces between the weights with almost explosive energy.

The two forms of roll which are described are adapted to crushing rock, ore, cement clinker, and all similar materials. They are manufactured by the Sturtevant Mill Co., of Boston, Mass., to whom we are indebted for the information from which this description has been prepared.

ENGINEERS AS TRACK APPRENTICES ON THE ILLINOIS CENTRAL R. R.

The Illinois Central R. R. has the distinction of being the first and almost the only railway to take systematic steps towards putting the maintenance of way in the hands of men trained both as engineers and as practical trackmen. On most roads this work is mainly in the hands of men who have risen from the ranks of section foremen, and above whom are engineers with frequently but a slight knowledge of the practical work on the track and the conditions under which this work is carried out. Under modern conditions of railway construction and service, the maintenance of way is becoming more and more a matter requiring engineering skill and training, as well as familiarity with the work of the track, bridge and construction gangs. This is gradually being realized by the higher officials in railway service, but at the same time it is difficult to obtain men having the necessary qualifications. The question of the advisability of training young engineers in the track forces, with a view to their becoming section foremen, supervisors, roadmasters, and engineers of maintenance of way, was discussed in our issue of Oct. 19, 1899, in an editorial on "The Organization of Railway Engineering and Maintenance of Way Associations." In that article we described the system of track apprenticeship, as introduced on the Illinois Central R. R. by Mr. John F. Wallace, M. Am. Soc. C. E., Second Vice-President of the road, and we have recently received from Mr. Wallace a copy of a letter written by him to Prof. Wm. D. Pence, of Purdue University, giving the results of the experience with this system. The idea is to take young engineering graduates and place them with section gangs for a year or two, then make them foremen, then supervisors, and finally roadmasters. By this means it is hoped to have always a supply of good available material to draw upon for the better positions in the maintenance of way department, from among men who are engineers with a practical knowledge of track work. The results of the operation of this system during the three years in which it has been in operation are given by Mr. Wallace as follows in the letter above referred to:

As regards our track apprentice system, I find that since this system was introduced in May, 1897, we have on our register the records of 120 track apprentices. Of these 13 "flunked," either upon being informed as to the exact nature of the work on their arrival upon the scene of their labors, or after a few days' experience of it; 3 resigned after several months' work, and, I understand, discontinued the engineering profession entirely; 9 resigned some time after they engaged with us, either to accept better positions with other roads or to go into other lines of business; 12 worked only temporarily, during a few months' vacation, and afterwards returned to school or college to finish their education; 39 are at present employed on our engineering corps. The remainder of the 120 are still employed as track apprentices, some of them having been engaged in the Engineering Department for a short time whenever their services were required, and having returned to track work rather than remain idle during the winter season.

Of the 39 who have been taken into the engineering staff, 2 now rank as Assistant Engineers at $100 a month; 1 as Office Engineer at $83.33; 3 as transitmen at $75; 10 as rodmen at $60; 18 as chainmen at $50 a month. Of those who remained in the service as track apprentices, one has been promoted to the position of Foreman in the Road Department.

Classifying them from an educational standpoint, of those who are now in the service of this company, 36 have received the full degree of Civil Engineer, after having graduated from universities or technical schools; 27 have studied civil engineering for from one to 3½ years; 23 were educated in high schools or manual training schools. The remainder took a good common school education and completed their course in the school of hard work and adversity.

While very few of these young men have followed the path originally outlined, we are nevertheless well satisfied with the system, and expect to continue it. We have made track apprenticeship the doorway to the Engineering Department. The lower positions in this department are filled entirely from among the track apprentices, their subsequent promotion depending on their relative fitness. It does not follow that even the best engineering graduate will show the necessary amount of ability and control of men to make them successful in the Road Department. Neither does it follow that because the track apprentices are drafted into the Engineering Department their experience as track apprentices is of no value to them. We frequently fill the most responsible positions in the Engineering and Operating departments from the engineer corps. Young men who have worked for a few months as track apprentices and are then promoted to be Assistant Engineers, may become Supervisors or Roadmasters. The practical experience they obtained while serving as track apprentices may then be one of the principal means of their ultimate success.

During the past ten years four members of the engineer corps have been promoted through the Road Department ranks to the grade of Division or Assistant Division Superintendent; 7 have filled the position of Roadmaster, which on the Illinois Central R. R. is one of considerable importance, and corresponds to that of Engineer of Maintenance of Way on other roads; 4 hold positions as Supervisors, corresponding to the ordinary Roadmaster.

In spite of our effort and desire to fill our Road Department with educated, capable men, we find it difficult, whenever there is a vacancy in the higher positions, to find a suitable man to fill it. This is mainly because executive ability and the power to control men is a rare faculty. Men are born, not educated, to command, although the efficiency of the born commander is improved by education. I feel that even if we secure only one good man out of ten, the system will have been successful and will recompense us for our work and trouble in connection with it.

REPORT ON SEWAGE SLUDGE DEPOSITS ON THE EXPERIMENTAL COKE BEDS, LONDON, ENGLAND.

In our issue of Nov. 9, 1899, we gave an account of experiments with the filtration of crude sewage through coke at the Crossness outfall of the sewerage system of London. The information was drawn from reports by Prof. Frank Clowes, Chemist to the London County Council, and Dr. A. C. Houston, in charge of the bacterial portion of the investigation. Beds 4, 6 and 13 ft. had been tested at that time. The coke used is from gasworks, and is about the size of walnuts. The beds are filled to the surface with sewage, which is then allowed to remain for some hours in contact with the coke and entrained air, after which the effluent is drained off and the beds are given a rest.

We have just received a report supplementary to the one named above, presenting an interesting study of the character of the sludge deposits, possible means of excluding from the beds that part of the sludge of an organic nature that is not readily decomposable, and qualitative studies of the bacteria retained on the coke. We quote Professor Clowes' section of the supplementary report in full, as follows:

(1) Aeration of Coke Beds.—The preliminary experiments which indicated that the aeration of the coke beds was satisfactory (Second Report, p. 9) have been repeated, and the new results fully corroborate those which were quoted in the second report.

(2) Deposit on the Coke.—It was stated in the Second Report [p. 6 (d)] that "the surface of each piece of coke had in course of time become covered with soft matter;" and it was ascertained that this matter contained some fine coke particles and sand grains, cotton and woolen fibers and diatoms, but consisted largely of chaff, straw and woody fiber.

As this deposit on the coke increased, the sewage capacity of the coke bed decreased. A series of gagings of capacity of the 13-ft. coke bed showed that the decrease of capacity was proceeding at the rate of 1% of the original capacity per week. As this threatened a short life to each coke bed when it was dealing with raw sewage, experiments have been undertaken with the view of preventing, or at any rate considerably retarding the choking of the coke bed.

As has been already stated, the matter which was de-

posited upon the coke consisted largely of cellulose (chaff, straw and woody fiber). Cellulose is known to be only very slowly acted upon by bacteria. It seemed advisable, therefore, to attempt the separation of these cellulose matters from the raw sewage before it was introduced into the coke beds.

A few rough preliminary experiments were made in order to ascertain whether this matter could be separated by sedimentation without separating the putrescible matters of the sewage.

In the first experiment the raw sewage was allowed to flow, on its way to the coke bed, through a wooden trough which had several cross-divisions reaching half-way from the bottom to the top. In this trough the matter which separated by sedimentation consisted almost wholly of particles of chaff, straw and woody fiber. This sediment remained perfectly inoffensive when kept in the moist or in the dry condition. The dry matter burned readily when it was kindled. The portion deposited at the entrance to the trough contained about 52% of combustible matter, whilst that deposited near the end of the trough contained about 70%. This result appears to indicate that the waterlogged cellulose matters may be separated by sedimentation, and may subsequently be dealt with in a furnace or destructor.

In order to ascertain how far this process of rapid sedimentation prevented the choking of the coke bed, another preliminary experiment was made by feeding the raw sewage into the coke bed through a tank. The sediment thus obtained was not foul. The rate of choking of the coke bed was reduced from about 1% per week of its original capacity to 0.64%.

A further trial is now being made by filling the coke bed through a settling trough; and in this trough the rate of flow of the sewage will be varied, with the view of ascertaining the rate which is most suitable for depositing grit and cellulose without allowing deposition of foecal putrescible matters.

Dr. Houston describes pretty fully his studies of the bacteria found on the particles of coke, which were directed largely to the pathogenic qualities of the germs and particularly to the presence of the tubercle bacillus. His conclusions are as follows:

It may be concluded from these experiments that, even if some of the "acid-fast" bacteria collecting in the coke beds are those of the tubercle bacillus, they have for the most part lost their infective power. Nevertheless, the single positive experiment recorded tends to destroy the belief that none of the bacteria in question are those of tubercle, or that, being tubercle, they have all lost their infective power.

That some of the "acid-fast" bacteria should be those of the bacillus of tuberculosis is not so remarkable when the source of raw sewage is taken into consideration, and when it is remembered that each fragment of deposit collecting on the coke in the filter beds probably represents the flow of hundreds of gallons of sewage.

The practical bearing of these experiments, apart from the scientific interest attaching to them, would seem largely to depend on whether the effluent is discharged into a stream used for drinking purposes, or otherwise. In conclusion, no further claim is made than this:

(1) In crude sewage, in bacterial coke beds, and in the effluent from bacterial beds, there are certain bacteria which, after being stained with hot carbol-fuchsin, resist decolorization with 33% nitric acid.

(2) Some of these "acid-fast" bacteria cannot, with certainty, be morphologically distinguished from the tubercle bacillus.

(3) In one instance a guinea-pig inoculated with the deposit accumulating on the coke of a bacterial bed died, and presented, on examination, the appearance of death from tubercle infection, and sections of its organs, when appropriately stained, showed the presence of numerous tubercle bacilli.

A NEW ROTARY CONCRETE MIXER.

The increasing use of concrete in engineering and architectural works is leading to the introduction of a number of special appliances for mixing and handling the concrete, and we illustrate herewith a rotary drum mixer which has recently been in use on the track elevation work of the Chicago, Milwaukee & St. Paul Ry., in Chicago. On this work all the abutments and retaining walls of the subways carrying the streets under the tracks are built of monolithic concrete, requiring a great quantity and a continual supply of materials.

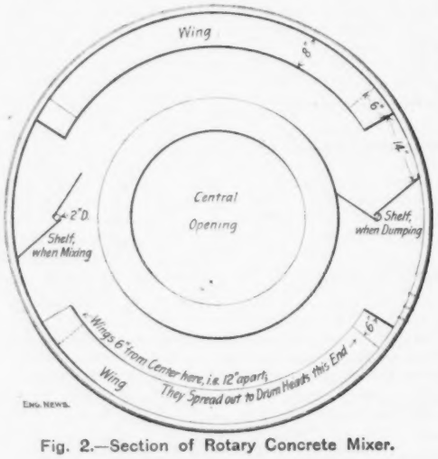

Fig. 2.—Section of Rotary Concrete Mixer.

The machine consists of a rotating drum with a large central opening, and the drum is mounted on roller bearings which support it by the rim or flange of the central opening. The materials are dumped into the bottom of the drum on one side, and the concrete is delivered from the upper part of the drum, on the other side. The drum is driven by gearing, by means of a circular rack on the periphery. Fig. 1 is a view of the delivery side, showing the inclined delivery chute and the levers of the dumping blades. The charging side is similar, except that the central opening is obstructed only by the water supply pipe. Fig. 2 is a diagram showing the two sets of mixing wings or baffle plates, and the two mixing and dumping blades. The former are perpendicular to the periphery of the drum, and are set in a diagonal or flaring position, 12 ins. apart at the narrowest portion and spreading out to the heads of the drum at the other end. These wings throw the material towards the delivery side of the drum. As the materials are thrown into the drum the blades and the friction against the side carry them up, while the face of the material continually slides and rolls down over the rest in an attempt to assume the angle of repose. This produces a rubbing as well as a mixing action, and in this way a very complete intermixing is obtained. After the required number of revolutions has been made, the position of the blades is changed by levers on the head of the drum, so that they form troughs (as shown at the right of Fig. 2). These carry the concrete up to the top of the drum, and drop it into the inclined sheet iron chute, at the end of which the wheelbarrows are placed.

The drum is 6 ft. diameter and 3 ft. wide inside, with a capacity of about 75 to 100 cu. yds. of concrete per day of ten hours. The speed is from ten to twelve revolutions per minute. The water is first admitted by a pipe from the measuring tank shown in Fig. 1, the cement, gravel and stone being then shoveled in in the order named. On the track elevation work above referred to, the gearing was driven by a belt from a 12-HP. portable gasoline engine, built by Fairbanks, Morse & Co., of Chicago, and running at 235 revolutions per minute. The concrete in this case was composed of 1 part of cement, 3 parts of gravel (67% coarse sand and 33% small stones) and 4 parts of 3-in. stone, while the facing consisted of a 1½-in. layer of mortar composed of 1 part of cement to 2 parts of sand. When work was commenced on any abutment it was carried on without cessation until it was completed.

This drum mixer, which has also been employed on other works, is the invention of Mr. Ernest L. Ransome, President of the Ransome & Smith Co., 149 Broadway, New York, N. Y. This firm makes a specialty of concrete construction. Mr. Ransome states that the efficiency of the machine is shown by the fact that he has obtained with it concrete of twice the compressive strength of concrete carefully mixed by hand (and turned over seven times), similar materials being used and under similar conditions. The tests were made when the samples were one week old. He further states that great benefit is to be obtained by prolonged mixing, concrete that has had a thousand turns being stronger than that which has had only a hundred turns.

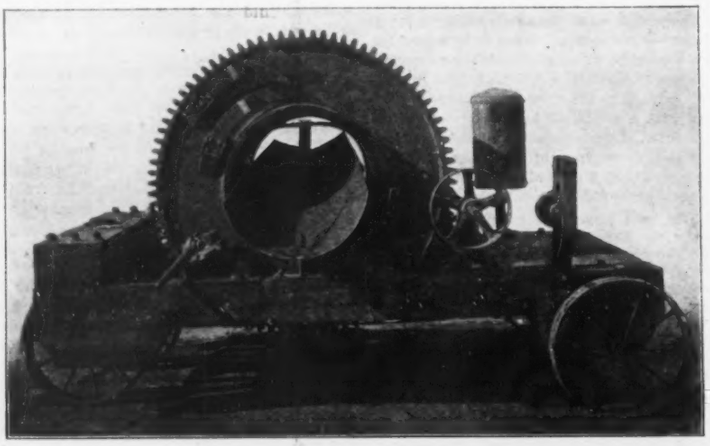

FIG. 1.—ROTARY CONCRETE MIXER.
Ransome & Smith Co., Makers.

AIR AS A LUBRICANT.*

By Herman S. Heichert.†

Ordinary air is now being used with good results for illustrating the action of a lubricant in a journal bearing, in a machine designed by Prof. Albert Kingsbury, of the Mechanical Department of the Worcester Polytechnic Institute. The machine is at present a part of the Mechanical Laboratory apparatus, and a series of experiments are now in progress for the purpose of further investigation.

The machine consists of a steel piston or short shaft, Fig. 1, to be rotated, and a cast-iron ring or cylinder which acts as a bearing for the shaft, the whole being supported on rollers mounted on a suitable frame, as shown in the sketch. The shaft weighs 50½ lbs., is 6¼

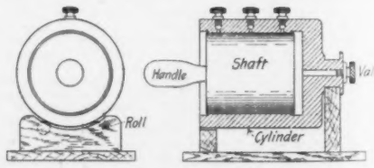

Fig. 1.—Shaft and Journal, Showing the Action of Air as a Lubricant.

ins. long and 6 ins. in diameter, and its weight constitutes the total downward pressure on the bearing. The diameter of the cylinder is slightly less than $\frac{1}{2,000}$ in. larger than the shaft—a fairly loose fit. Both cylinder and shaft are ground to exact parallelism.

The principal results so far attained are: (1) The demonstration of the formation of a film of air between the cylinder and shaft when rotating, so that the shaft is actually floating on the air and is not in contact with the cylinder at any point. (2) The determination of the position of the shaft relative to the ring, whether eccentric or concentric, and changes in its position with changes

*From the "Rose Technic."
†Worcester Polytechnic Institute, Worcester, Mass.

in speed of rotation. (3) The determination of the pressures existing in the film of air at different points around the shaft and the change of these pressures with change of speed. These results were accomplished in the following manner:

The cylinder is set horizontally, the shaft inserted in it (both being perfectly clean and dry) and rotated with the hand by the handle shown at the end. It can be turned with difficulty at first, and the harsh, grating sound of metal rubbing on metal will be heard. With an increase of speed, however, this grating ceases and the force required to turn the shaft is materially decreased until, after a few revolutions, the shaft becomes entirely free from the cylinder and rotates on the film of air between. Set rotating at, say 500 revolutions per minute, it will continue to rotate four or five minutes. If allowed to run, the speed gradually decreases from the start until suddenly the piston breaks through the intervening layer of air and a few more revolutions suffice to bring it to a sudden stop.

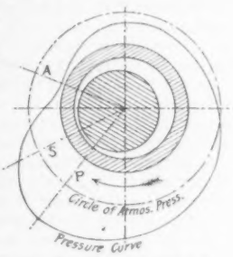

Fig. 2.—Diagram Showing Relative Position of Shaft and the Distribution of Air Pressure.

If a more conclusive proof is required that the shaft is entirely separated from the cylinder, an electric bell may be included in a circuit of which the shaft is made one terminal and the cylinder the other, when it will be found that the bell is silent as long as the shaft rotates at any considerable speed.

To determine the position assumed by the rotating shaft in relation to the cylinder, it is only necessary to remove one of the plugs shown in the top of the cylinder and insert in its stead a micrometer screw. We have then at once a means of determining the position of the shaft by rotating the cylinder on its supporting rollers and reading the micrometer screw at the several positions around the circle. The electric bell may again be used to determine when contact has been made between the micrometer and the piston. Tests of this character show that the piston occupies a position below the center and in advance of the lowest point on the cylinder circle. For example, if in Fig. 2 the shaft be represented as rotating in the direction of the arrow, the point nearest the cylinder will be in the vicinity of S. The higher the speed of the rotation the more nearly will the axis of the shaft coincide with the axis of the cylinder. The point S will also shift its position somewhat with variations of speed. By reasoning alone one would probably conclude that the point S would lie near the bottom, but to the right hand side of the vertical diameter, the piston rolling up on this side before any sliding action begins. In stopping and starting this is no doubt true, but as soon as the speed is sufficiently high to cause contact to cease the shaft will occupy a position as described above.

The third point, a determination of the pressures existing in the film of air, is made in the following manner: A connection is made by means of a small rubber tube between one of the holes drilled in the cylinder wall and a mercury manometer. This done, and the shaft set rotating, the pressures may be measured in inches of mercury by rotating the cylinder on the supporting rollers (as was done in finding the position of the shaft), to as many points around the shaft as was desired. Minimum pressure will be found at about the point A, where there will be a partial vacuum, the least noted being about 2 lbs. less than atmospheric pressure. The point of maximum pressure will be found near P, a little to the right from S, and a pressure of 3 lbs. per sq. in. above atmospheric pressure has been reached at some speeds. The pressure curve in Fig. 2 is a fair sample of the pressures existing around the shaft, pressure at any point being laid off to scale on a radius through that point, from the circle of atmospheric pressure. Leaving friction out of account, the resultant vertical force should, of course, be equal to the weight of the piston. This peculiar distribution of pressures would seem to indicate that the air is drawn out of the wedge-shaped opening near the top of the cylinder and forced into the similarly-shaped opening at the bottom. Pressures along an element of the cylinder near the bottom will show an increase from zero at the ends, which are, of course, open to the air, at atmospheric pressures to a maximum at the middle. An element near the top will show atmospheric pressure at the ends and a less pressure as the middle is approached.

The cylinder, as will be noticed, is closed at one end and is air-tight, except when the valve is opened, which is necessary when the piston is to be withdrawn or inserted. If both ends are left open, it is found practically impossible to level the cylinder with sufficient precision to prevent the piston traveling axially when rotation on its air lubricant—another proof of the small amount of friction. A few drops of oil allowed to run into the bearing will cause sufficient friction to stop the shaft in a very few revolutions, likewise a little rust or slight abrasion on one of the surfaces, will cause the experiments to fail. An article by Prof. Kingsbury, giving complete descriptions and data of experiments performed several years ago can be found in Vol. IX., Jour. Amer. Soc. Naval Engrs.

METHODS OF CHECKING ARITHMETICAL CALCULATIONS.

By Willis Whited.

The computer often has long and complicated calculations to make which cannot be thoroughly checked, and as the accuracy of the result may be very important, his anxiety lest he make a mistake, may absorb more nervous force and time than the actual calculations. Generally, the greater part of the time and nervous energy are spent on the arithmetical part of the work in which mistakes are not apt to be so easily detected as in the other parts of the work. If it is not practicable to have somebody else go over his work, an excellent way to detect non-arithmetical mistakes is to go over it himself some days afterward.

If logarithmic or trigonometrical tables are used it is a good plan to employ different tables in reviewing the work; not so much on account of possible errors in the tables, as because other tables being differently arranged present a different appearance and employ other methods of interpolation.

In Addition, all the proof that is generally needed, if the computer is reasonably skilful, is to add both up and down, unless the column is very long or there is liability of getting the columns mixed; in such cases the column of numbers should be copied on a separate piece of paper and divided into parts. Another excellent check is to add again, adding in the carried figures after the others, instead of before, or vice versa. In Subtraction, adding the subtrahend and remainder is all that is needed; but it is a good plan to cover up the minuend while doing so. In Multiplication, the simplest check is by excess of 9's, and it is pretty reliable unless the numbers multiplied are very large. There is, however, always a possibility of getting one figure too small, and another the same amount too large in the product, or of making the mistakes illustrated:

548	548
206	26
3288	3288
1096	1096
14,248	112,888

Mistakes of this class would not be detected by excess of 9's; but the first one probably would be found, and the last two surely would be, by excess of 11's. The latter method is a little more trouble than the former. If the numbers are large it is a good plan to check the partial products separately, and, of course, prove the addition by one of the methods above mentioned.

An excellent plan, one which avoids nearly all mistakes and often saves much time is to form a table of the products of the multiplicand as follows:

1.	548	3.	1,644	5.	2,740	7.	3,836	9.	4,932
2.	1,096	4.	2,192	6.	3,288	8.	4,384	10.	5,480

Form the table by addition and check by multiplication, where it can be done by multiplying by 2 or 5, and the last will prove the whole. This table is easily constructed and saves much time where the same multiplicand is used more than once, or where the multiplier is very large.

One of the best proofs, although somewhat laborious, is to reverse the position of the multiplier and multiplicand: this proof is almost absolute and has the advantage that if a mistake is found to exist it gives a pretty good clew as to its location. This has the same value whether the numbers are large or small. Another proof which is easily made and is practically absolute, is to divide the product by some aliquot part of the multiplier, which does not contain 2, 3 or 5 as a factor, and see that it divides exactly. If the same factor occurs also in the multiplicand it is well to use its square. If the multiplier is not readily factored it can be used as it is. As the quotient of this division is not required it will save time to add or subtract multiples of the factor chosen in such a manner as to reduce the number of figures in the product as rapidly as possible, as follows:

	2896358
	− 26
	17378148
Take the factor 13.	5792716
	75305308
	+ 52
	7530536
	− 65 − 26
	103051
	+ 39
	10309
	− 39
	1027
	+13
	104 = 8 × 13

which proves the work. This method is very convenient where the multiplier is not very large.

If the numbers multiplied contain decimals and all figures below a certain value are rejected, about the only available proof is to reverse the position of the multiplier and multiplicand as above mentioned, although a method similar to the following can sometimes be used to advantage:

68.74932	
526.8479	
34,374.660	
1,374.986	
412.496	
54.999	
2.750	
.481	
.062	
36,220.434	1,000.0000
27,409.728	526.8479
4,812.452	473.1521
206.248	
6.875	
3.437	
.137	
.007	
68,749.318	

It will be seen that in the first multiplication the figures of the multiplier are used from left to right, and the decimals beyond three places are omitted, considerably abbreviating the work. The partial products below 36,220.434, are formed by again multiplying the multiplicand by the complement of the multiplier (473.1521) in the same manner, and adding the partial products as shown. The sum should equal the original multiplicand with the decimal point removed three places to the right.

This method of proof is practically conclusive and is quite easily applied if a table of multiples has been formed similar to that given above.

Division may be checked by excess of 9's or 11's, the latter being far better, although not quite so easily applied: the mistakes in the following examples would not be detected by excess of 9's, but would be by excess of 11's:

26	89765	33152	26	272845	1494
	78			26	
	117			128	
	78			104	
	39			244	
	26			234	
	136			105	
	130			104	
	65			1	
	52				
	13				

The table of multiples is of greater assistance in division than in multiplication, and is peculiarly applicable in both when a few decimal places are omitted. In the latter case the tests by excess of 9's and 11's are not applicable. Probably the only available proof is to multiply the divisor and quotient together and add the remainder. If a table of multiples is used the quotient may be used as the multiplier, otherwise the divisor should be used as the multiplier. Occasionally time will be saved by multiplying the divisor by the arithmetical complement of the quotient, adding the dividend and subtracting the remainder as follows:

42	3750	89	3,750
	336		42
	390	100 − 89 = 11	42
	378		4,212
	12		12
			4,200 = 42 × 100

which proves the work.

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It is a pleasure to record that Vermont has joined the small company of states that are making systematic chemical and biological examinations of their public water supplies. For the present four analyses a year will be made. The only aid requested from the communities directly interested is the payment of transportation on the samples and the collection of the samples, the latter to be done by the various local health officers. Those at all familiar with Vermont know that many villages have small gravity pipe lines supplying a few families, on a co-operative plan. It is proposed to include all supplies serving twelve or more families. It is also the intention to make a study of the principal streams of the state. The work is to be done at the Laboratory of Hygiene of the State Board of Health, at Burlington. Mr. J. H. Linsley, M. D., is director of the laboratory.

Besides the great direct benefit which it will be to the citizens of the state, the work will soon more than pay for itself by increasing the attractiveness of its many charming villages and towns as summer resorts. It is getting to be recognized that city dwellers in escaping to the country for the summer often incur greater dangers to health than if they remained in the city, on account of the poor sanitation of many country towns. One of the chief dangers of the vacation period is the impure water in country farmhouses and villages. Every dollar spent in guarding the healthfulness of any community or state in these days of sanitary awakening will be returned many fold in the near future, besides adding to the general prosperity, health and happiness of all concerned.

In the February issue of the Proceedings of the American Society of Civil Engineers we note several diagrams issued by the finance committee that are interesting to the membership and creditable to those in charge of the expenditures of the Society between 1886 and 1899. Under the head of receipts per member, the line is a fairly steady one, ranging from about $19.50 to $22 per member, ending in 1899 with $21.50. The expenditures per member averaged about $20 from 1886 to 1891; they rose to nearly $23 in 1893, and then rapidly descended to $14 in 1896. Since 1897 this expenditure has gone up to $18.25, but this is largely due to extra work in reclassifying and indexing the library, and in keeping the Society House open daily—except Sundays—for 13 instead of 8 hours. The net cost of publications per page also shows a gratifying decrease. From $6 per page, in 1886, this curve rises to $10 in 1888, but drops to $5 in 1892—with some fluctuations between; it rises again to $6.50 in 1893, and then steadily declines to $3.25 in 1899. It should be mentioned that until 1892 the salary of the secretary did not appear in the cost of publications, as it does now; and for the years 1886-92 the cost of publications is correspondingly lower than it should be to compare with the years following 1892. The total salary cost per member fluctuates slightly, but is now almost exactly what it was in 1886. The ratio of expenses to receipts has fallen from 90% in 1886 to 85% in 1899. The total membership, however, has increased by 125% since 1886, and the total editions of publications has increased in practically the same ratios. The total current receipts have gone up steadily from about $21,000 in 1886 to $47,000 in 1899; and while the total current expenditures rose practically with the receipts up to 1893, between 1893 and 1896 they dropped from $38,500 to less than $28,000; they then rose to $40,000 in 1899, along with expenses incident to the new Society House. As a whole, the efforts of the finance committee show a very creditable trend towards increased economy in managing the affairs of the Society.

THE SUBSTITUTION OF ELECTRIC TRACTION FOR LOCOMOTIVES ON SUBURBAN RAILWAYS.

The disappearance of the steam locomotive and the substitution of the electric motor in its place has been a favorite theme of the prophets for more than a decade. About the time when the electric motor was winning its chief triumphs over the horse, the cable and the steam dummy, they were most vociferous and most sanguine. Each case where electricity was substituted for steam was heralded abroad and made much of as a sure token of the certain, complete and early victory of the electric motor over its older rival.

During the past five years, however, these prophecies have been less frequently heard. The limitations of electricity in the field of railway operation have become more evident for one thing. For another, the much-advertised progress in the elimination of the locomotive has come to a stop. It is only occasionally, therefore, that some particularly sanguine seer lifts up his voice to foretell anew the decline and fall of the locomotive and the reign of the motor in its stead. Engineers at the present day are generally agreed, we believe, that the movement of heavy through trains, either freight or passenger, by electric motive power is at present as visionary a dream as projects for mechanical flight. So far as heavy freight traffic is concerned it is even more visionary, for the modern freight locomotive is one of the most economical and efficient machines in existence; and it is difficult to imagine how electric traction could even approach competition with it.

The debatable ground in discussing the question before us, then, is practically confined to the local passenger service. On another page of this issue we reprint a paper just read before the Institute of Electrical Engineers in which this question is discussed. The author of the paper, Mr. E. C. Boynton, is connected with the New York, New Haven & Hartford R. R., and as that company has had the largest experience of any railway in this country in the substitution of electricity for steam, what Mr. Boynton has to say will be read with much interest.

He holds that there are two classes of traffic in which electricity can be profitably substituted for steam: suburban traffic and what may be called "inter-city" traffic, or passenger travel between adjacent towns in a densely populated district. The steam roads have lost heavily in both these fields through the competition of the electric street railways. Can they regain it by the substitution of electric motors for the steam locomotives and will it pay to make the change? Mr. Boynton answers both these questions in the affirmative, and his paper gives his reasons for this position. We propose to present some reasons for holding a contrary view; or rather for holding that no hard and fast rule can be laid down, that each case must be considered by itself, and that the probabilities are still against profit in the change from locomotives to electric motors.

It will be conducive to clear thinking if we consider separately the two reasons urged for the adoption of electricity: first, to increase traffic and second, to reduce operating expenses.

It is urged that because the electric roads have taken away the steam road's passenger traffic, the way for the latter to get their traffic back is to adopt electric motive power. This theory overlooks the fact that the electric propulsion was a mere incident in the competition. The reasons why the trolley takes passengers from the steam road are first its lower fares, second its more frequent cars, and third (and most important of all, in our opinion) the fact that the electric road carries passengers from one destination to another and not from a railway station in one city to the station in another. The steam railway can reduce its fares and can run more frequent trains, and has in some cases done this and thereby regained a part of its traffic; but until it can run its cars through the streets to pick up and leave its passengers it will be heavily handicapped in competition with the trolley. If steam railway companies can obtain permission to do this as a result of adopting electricity, it would be a powerful argument for its substitution in suburban service on many roads. Such permission, however, is seldom likely to be granted; and even if it were obtainable, the operation of independent cars at frequent and irregular intervals over tracks on which freight trains and perhaps express passenger trains are also run is a problem not easy of solution.

The point which must be borne in mind in canvassing any proposition of this sort is that the present rates of speed must be maintained. It is by virtue of its higher speeds, chiefly, that the railways are still able to compete with the electric lines paralleling them. To make these speeds with safety, accepted safe practice in steam railway operation must be adhered to. There must be some sort of systematic train dispatching and some provision for keeping safe space intervals between moving trains or cars. The happy-go-lucky system of car movement that prevails on most electric railways will not do at all. The proposition to switch off cars here and there to run through the streets, picking up and leaving passengers and joining the main line again at such a time as the delays in street traffic permitted would disarrange any operating schedule, cut down the safe speed of train movement, and thus nullify to a considerable degree the advantages expected to be gained.

Leaving out, then, the proposition to run cars through city streets, let us see what else electric operation on steam roads can do to increase traffic. The avoidance of the smoke of the locomotive may count for a little, especially in cities where soft coal is used in suburban train service; yet most of the fastidious passengers whose patronage would be thus gained are probably already riding on the steam trains, since the locomotive smoke is on the whole less objectionable than the street dust and noise, the crowded cars, the frequent jerky starts and stops and the other discomforts of the electric street railway.

The real practical advantage to the passenger which the steam railway can offer by adopting electricity is more frequent train service, and this is certainly an important item. It is more important, however, in inter-city traffic than suburban traffic. In the former there may be a fair distribution of the traffic throughout the day. In suburban traffic three-fourths of the entire traffic is compressed into two hours of the morning and two hours at night. The railway manager has to

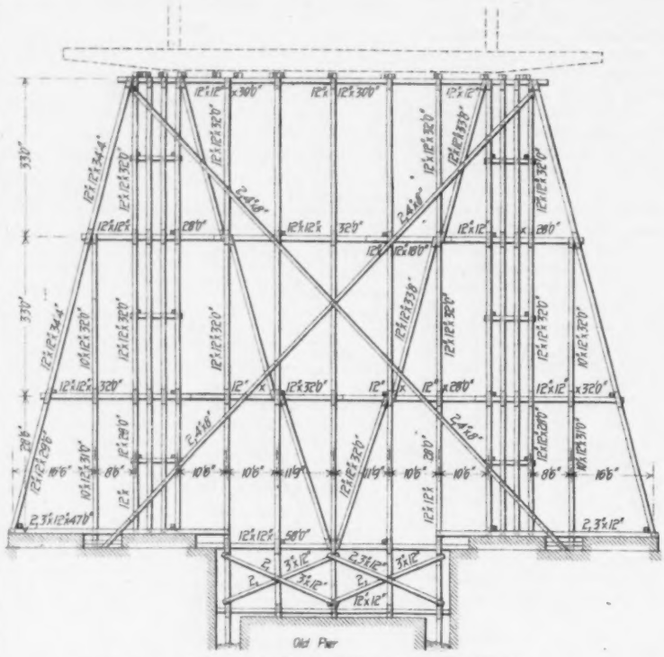


FIG. 2. SPECIAL BENT CONSTRUCTION OVER TOWER MASONRY.

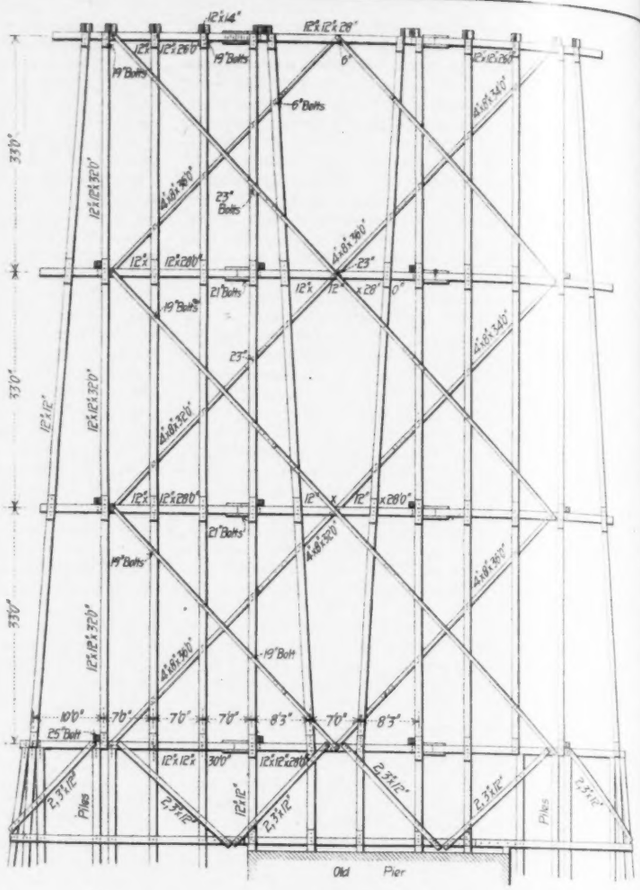


FIG. 3. NORMAL BENT CONSTRUCTION BETWEEN TOWERS.

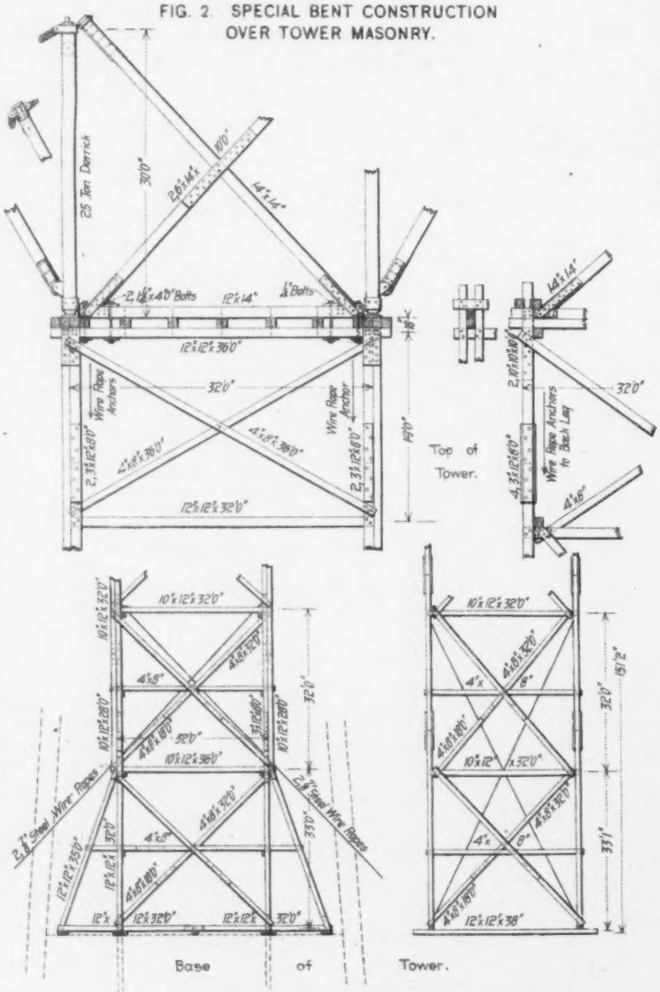


FIG. 7. DETAILS OF TIMBER TOWER FOR ERECTING MAIN STEEL TOWER.

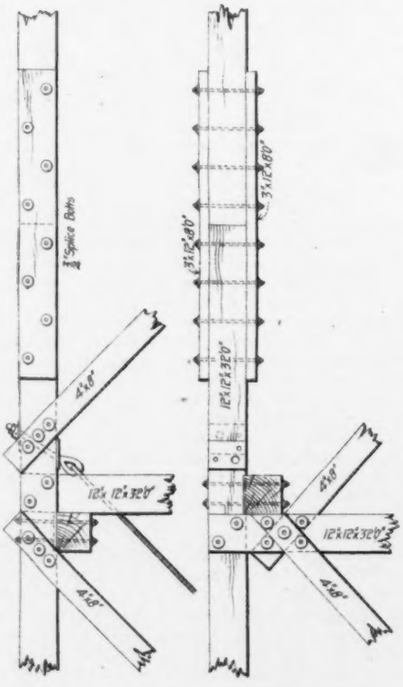


FIG. 9. DETAILS OF CONNECTION AT BACK POSTS OF TOWER.

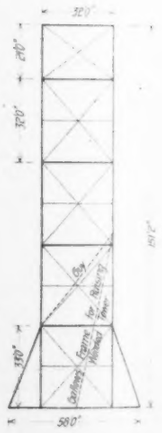


FIG. 8. DIAGRAM SIDE ELEVATION OF TIMBER TOWER FOR ERECTING STEEL TOWER.

FALSEWORKS FOR ERECTING THE MANHATTAN TOWERS A

L. L. Buck, M. Am. Soc. C. E., Chief Engineer, New

New Jersey Steel & Iron Co., Trenton, N. J., Contractors for Steelwork and Erection.

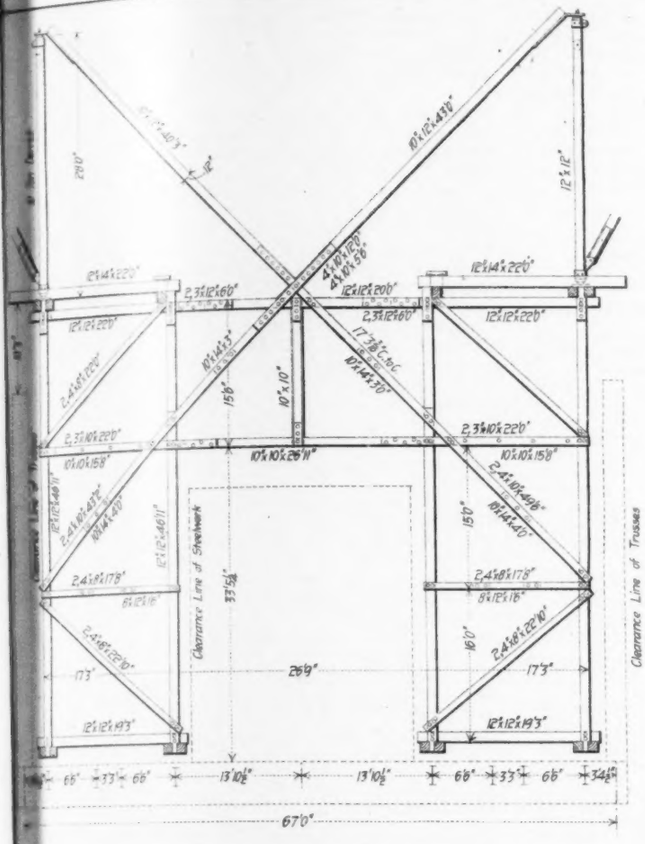


FIG. 12. END ELEVATION OF TRAVELER FOR ERECTING SHORE SPANS.

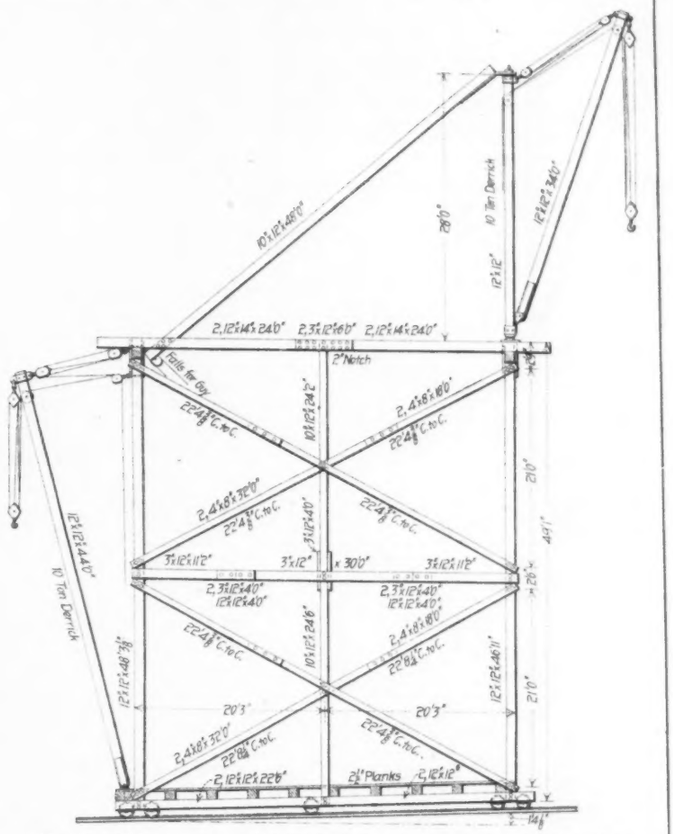


FIG. 11. SIDE ELEVATION OF TRAVELER FOR ERECTING SHORE SPANS.

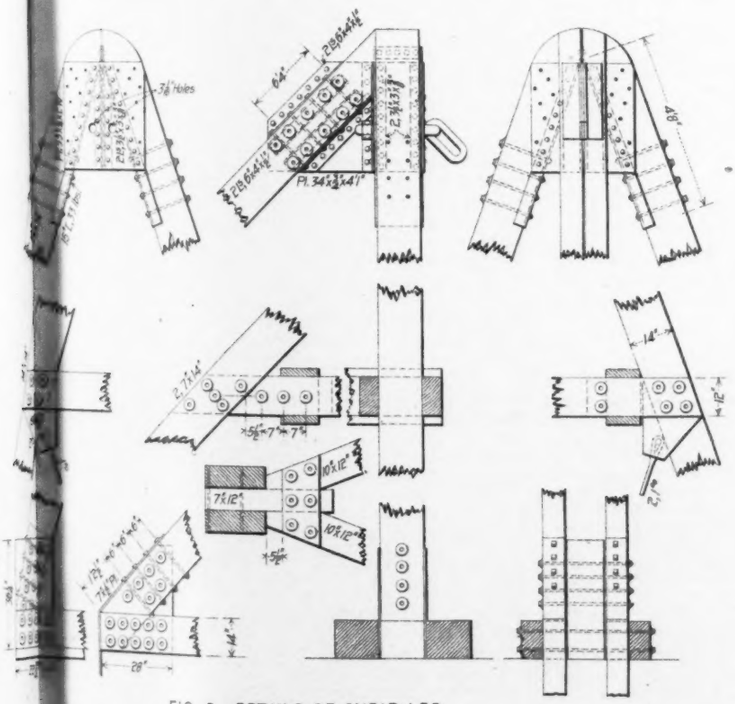


FIG. 5. DETAILS OF SHEAR LEG DERRICK FOR LIGHTER.

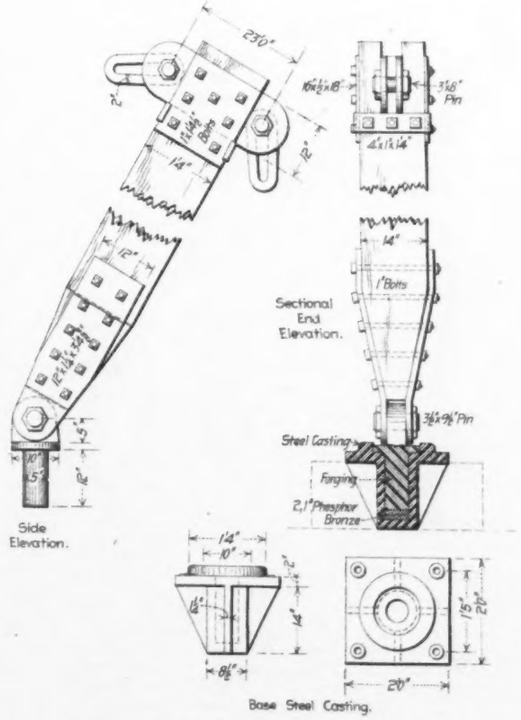


FIG. 6. DETAILS OF BOOM FOR SHEAR LEG LIGHTER DERRICK.

HATTAN TOWERS AND END SPAN; NEW EAST RIVER BRIDGE.

, Chief Engineer, New East River Bridge Commission.

rection.

The Terry & Tench Cons. Co., New York, Sub-Contractors for Erection.

CHAS. HART, LITH., 30 VESEY ST., N. Y.

solve the problem of providing rolling stock and train crews which can be profitably employed for only four hours out of the twenty-four. The railway president who expressed his preference for hogs rather than commuters had good reason for his choice.

Remembering, now, that the traffic capacity of a railroad depends upon the length of its trains, it will be seen that most suburban steam railways, were they to adopt electricity, must still move their cars in long trains during the rush hours. The interval between these trains can be little less than at present obtains on many roads, or they would be spaced too close together for safety. The traffic to be gained by substituting electricity, therefore, is the traffic during the other hours, and it is a matter for good judgment to determine in any particular case to what extent this class of traffic can be increased by running cars at more frequent intervals.

So much for the influence of electricity in increasing income. Now what can it do to reduce outgo? It can enable us to operate trains with a $2 a day motorman instead of a $4 a day engine runner, and to dispense with a fireman entirely. That is one aspect of the case. On the other hand, the $2 motorman will not be so reliable or so safe a man to bear responsibility for the safety of a train load of passengers, and pressure of one sort or another is likely to cause an increase in his wages when he is intrusted with the running of trains at high speed. It is also to be remembered that even though there be no necessity for a fireman in the cab of the electric motor, public opinion, legislation or perhaps self-interest may compel the placing of a second man there to share the runner's responsibility. Firemen have averted many accidents where death or sudden incapacity has overtaken their mate on the engine. Let us not estimate at too high a figure, then, the saving to be made in engine crew wages by adopting electricity, provided we mean at the same time to maintain steam railway speeds and standards of safety.

We have alluded above to the gain in passenger traffic to be made by running more frequent trains, or rather single cars, during the hours of light traffic. This is also electricity's chief claim for consideration from the standpoint of economy in operating expenses. On every suburban steam road there are numbers of trains run which do not pay the cost of moving them; yet they must be kept moving to satisfy the reasonable requirements of the public. A single electric car, with sometimes a trailer attached, could carry all the traffic, and with a train crew of two men instead of the four or five on the steam train. This is the aspect from which the electric motor proposition appeals most forcibly to railway managers, and the question that interests them is, will the greater first cost of electric traction be more than offset by the saving in moving cars and trains during the hours of light traffic?

Finally comes the question of the relative expenditure required to operate and maintain the two forms of motive power, and we have placed this last because it is the question of least importance. As we have just remarked, the electric system involves a much larger investment than locomotive equipment, and it can only be considered, therefore, where the volume of traffic, present or prospective, is sufficient to pay the charges on this increased investment.

How large this investment must be is little more than hinted at in Mr. Boynton's paper, but he quotes estimates of $80 to $90 per K-W. as the first cost of power stations. From these figures it seems likely that the power station alone would cost from once and a half to twice as much as the locomotives to give an equal train service, and to this must be added the cost of third rail, track bonding, feeders and other wiring and the electrical equipment of the cars.

In the comparison of operating expenses the electric system has probably a considerable advantage in the item of repairs. In the matter of fuel consumption the two systems stand on a nearly equal footing. The greater economy of the central station steam plant as compared with the locomotive is offset by the losses through the repeated conversions of energy, the loss in transmission, etc., which finally result in only 50 to 60% of the energy developed by the station engine being applied to propulsion of the cars.

In conclusion, we may repeat our statement above that each case must be considered on its merits. Our argument has been directed rather to the demolition of the general proposition that electric traction is more profitable than locomotives for suburban passenger traffic. In may be true, in few or in many cases; but at present the Scotch verdict "not proven" seems the proper one to render.

LETTERS TO THE EDITOR.

Concerning Free Opinions by Consulting Engineers.

Sir: In your apt and timely remarks on the subject of "dead beating" the engineering profession (March 1st), you include incorrectly my name among those engineers who reported upon the state canals without the payment of a single penny. I plead not guilty. While engineers are not exempt from performing any proper duties belonging to good citizens, they should not be expected to do important and responsible professional services without suitable compensation.

Though it may be personally noble and generous in individual members to do such work without pay, it does injustice to their profession by establishing in the public mind a low estimate of the value of engineering services.

Yours truly, Theodore Cooper.

New York, March 1, 1900.

(Our apologies are tendered to Mr. Cooper. By a slip of the editorial pen his name was substituted for that of Prof. Wm. H. Burr in the note above referred to.—Ed.)

Diagrams for Straight Line Compression Formulas.

Sir: In your issue of Feb. 15, Mr. John S. Fielding makes a statement regarding the diagram of straight line compression formula, published by me in the issue of Jan. 25, to the effect that the same idea in a more extended form had been previously published by him in your journal of Sept. 22, 1898. After carefully comparing the diagrams and explanation of the same by Mr. Fielding, with the later publication by myself, I am of the opinion that he has overlooked the difference in the methods of construction of our diagrams. It was a short method of construction for diagrams of straight line compression formulas which I endeavored to illustrate.

Mr. Fielding's diagrams are very complete and are in handy form for use. However, from the text accompanying them, it appears that he has worked out the variation (in pounds) in the value of the formula for each 1-in. increase in r, and plotted this increase on the diagram, in order to get the direction of the diagonals.

My method of construction enables one to lay out the diagonal lines for all values of r, by using only one value of the formula. My article did not contemplate any extensive illustration of various straight line formulas, but simply gave a short method which any one may easily and quickly apply to whatever straight line formula they have occasion to use. The maximum limit of $l \div r$ is also shown and no values are given for columns exceeding 180 radii in length. More slender columns than this are very seldom used.

Yours truly, O. W. Childs.

St. Louis, Mo., Feb. 22, 1900.

Cleaning Tracing Cloth and Restoring its Glaze.

Sir: Very few engineers or draftsmen seem to know that tracing cloth can be very quickly and easily cleaned, and pencil marks removed, by the use of benzine, which is applied with a cotton swab. It may be rubbed freely over the tracing without injury to lines drawn in ink, or even in water-color, but the pencil marks and dirt will immediately disappear. The benzine evaporates almost immediately, leaving the tracing unharmed. It must, however, be borne in mind that the surface has been softened, and must be rubbed down with talc or some similar substance before drawing any more ink lines. Charles W. Sherman.

3 Mt. Vernon St., Boston, Mass., March 2, 1900.

(Another wrinkle of interest to draftsmen which may be appropriately referred to in connection with our correspondent's suggestion we find in the "American Machinist" of Feb. 22, entitled "Old Phonograph Records for Rubbing Tracings and Drawings." We quote it as follows.—Ed.)

It frequently happens that mistakes or changes require the erasing of lines or letters on a tracing, and while this may be neatly done with a sharp eraser, the glaze on the cloth is destroyed, and, no matter how carefully the tracing is handled, the roughened portion catches the dirt, its beauty is soon gone, and it will not make clear prints.

Mr. Russell T. Kingsford, Chief Draftsman of the Rushmore Dynamo Works, Jersey City, has discovered that the glaze may be restored to the cloth after using the eraser by rubbing over the roughened surface with a piece of hard wax from an old phonograph record cylinder. The surface thus produced is superior to that of the original glaze, as it is absolutely oil and water proof.

In the Rushmore works all pencil drawings that go into the shop are first rubbed over with this wax, and it has been found that while common pencil drawings are soon destroyed by dirt and grease, those treated with the wax return to the drawing room after the completion of special jobs without the slightest blemish.

A Suggestion for Observations of Stream Turbidity, by the U. S. Geological Survey.

Sir: I have read with great interest the article in your paper of Feb. 22, 1900, by Prof. Thomas U. Taylor, of the University of Texas, upon the silting up of Lake McDonald in the Colorado River, at Austin, Tex. The deposit there found to have been formed in the short space of four years, whereby the cross-section of the reservoir has been reduced from 30 to 78.9%, and its cubical capacity diminished 38%, is of such remarkable volume as to lead one to infer that the silt carried in suspension by the waters of this stream must also be abnormally great.

Would not statistical information of the rivers of the country, in respect to their silt-bearing qualities, be of great value, and is not the Hydrographical Division of the U. S. Geological Survey in a position to furnish such information? It is taking daily readings of river stages at many points, and the addition of mid-day turbidity observations by the platinum wire method would add little or nothing to the cost of the service it is now rendering. If such information were available to the engineering profession, I believe it would be possible to predict, at least approximately, in advance of reservoir construction, such results as are found at Lake McDonald.

The rapidly increasing use of river water for municipal and power purposes, which is probable in the future, makes the need for such knowledge of our streams, as an aid to designers of controlling and purification works, of much more importance than has heretofore obtained.

I therefore propose that readers who favor the suggestion above noted write to the Chief of the Hydrographical Division of the U. S. Geological Survey, at Washington, D. C., and express their conviction of the utility of such knowledge. I am sure the officers in charge of this work need only to be convinced that there is a reasonable demand by engineers for such information in order to induce them to supply it and thereby increase the usefulness of this very efficient branch of the government service. Respectfully, Julian Griggs,

Columbus, O., March 2, 1900. M. Am. Soc. C. E.

(The general proposition for turbidity observations is a good one. It might aid somewhat in predicting the extent of silt deposits, and it certainly would be of great value in aiding the formation of conclusions regarding the quality of water for various purposes.—Ed.)

The Design of Foundations for Chimneys.

Sir: It may be of interest to a recent inquirer in your columns regarding the designing of foundations, and also to others, to read what Prof. Lang, of Hanover College, Germany, has said on this subject in a recent article on "Chimney Proportions" in a German technical weekly. His remarks are as follows:

The bounding planes of the sides of foundations should be inclined, enlarging the body of masonry as it deepens. Instead of a plane, the inclination may be made by use of a step construction. The proportions of the foundation should be such that the permissible load per square foot on the earth or soil found in the particular locality shall not be exceeded, and, also, that the wind-pressure against the chimney shaft shall not unduly increase the foundation load at any point. The inclination of the bounding sides with the horizontal should not be greater than 60°. It may be assumed that the supporting and sustaining capacity of earth of uniform character increases gradually with its depth.

In order that both the dead load and the effect of the wind-pressure may be properly taken care of, Hotop gives these formulæ:

Where

H_u = depth of foundation below ground level;

B_u = breadth of the bottom of foundation;

H = height of chimney above the top of foundation;

and

S_u = thickness of bottom plate of foundation,

$$H_u = \frac{H}{8}, \quad (1) \quad \text{and} \quad B_u = \frac{H + H_u}{8}. \quad (2)$$

For especially wide chimneys, the values of H_u and B_u should be enlarged proportionally.

Gaping of joints in chimneys is almost entirely avoided when the greatest pressure on the foundation does not exceed 35.55 lbs. per sq. in. or 5,120 lbs. per sq. ft. The base of the foundation, or foundation plate, should have a thickness $S_u \geq 1.64 + 0.01\ H$, where all dimensions are in feet. If the angle of the sides to bottom of foundation should be greater than 60°, it should be strengthened by steel beams or railroad rails placed crosswise in the concrete.

In looking over some government tests I find that in compression tests of cubes of cement concrete the corners of the cubes and their sides break off, or slough off, leaving the angle somewhat less than 60°; this bears out

Prof. Lang's statement. Thus, when designing footings or foundations of concrete, with no metal in them, it is of no advantage to have the angle of the bounding sides to the base much less than 60°. Again, there is no advantage in enlarging the foundation plate beyond what that angle will give, unless metal reinforcement is used.

Wm. Wallace Christie.

Paterson, N. J., Feb. 26, 1900.

Stresses in Circular Plates.

Sir: As regards the stresses in circular plates treated of by Mr. Godfrey in your issue of Jan. 4, p. 10, it would seem that Mr. Godfrey in his examination of Grashof's method has overlooked the fact that the quantity called f, in the formula $f = \frac{5}{6}\frac{pr^2}{h^2}$, does not stand for the maximum stress in the plate, but represents E , the product of E (Young's modulus of elasticity) by , the maximum "strain," or relative elongation, or contraction, of the outer fiber at the middle point of the plate (Grashof, Elasticitaet und Festigkeit, 1878, p. 336). That is, Grashof follows the criterion of security (see Lanza's "Applied Mechanics," pp. 869 and 870) that the maximum strain ε shall be no greater than what is found to be safe by experiments in simple tension or compression where there is no stress on the sides of the rod, or short block, and where consequently we have $E\varepsilon = f$ the working stress for that case (of simple tension or compression).

Where an outer fiber in the upper or lower face of the plate in question, however, crosses the middle of the plate, we find that a small cubical element of that fiber is subjected to equal compressive (or tensile) stresses on all of its four vertical faces. If this stress be denoted by q, its value in terms of the accompanying strain ε (the two horizontal faces being under no stress) is readily found from the relation (p. 868, Lanza; or p. 35, Grashof),

$$E\varepsilon = q - \frac{q}{m};$$

and substituting the value of $E\varepsilon = \frac{5}{6}\frac{pr^2}{h^2}$, with m = 3 as Grashof recommends, we finally obtain for the stress q,

$$q = \frac{5}{4}\frac{pr^2}{h^2} = \frac{1.25\,pr^2}{h^2}.$$

This value is seen to be greater than what Mr. Godfrey calls the average fiber stress (in extreme fiber) and is thus relieved from the criticism of "impossibility"; (though, after all, the maximum stress does not necessarily, in general, occur at the point of maximum strain).

In other words, q is the actual, or real, tensile stress acting on the cubical element (in lower face of plate); whereas f, or $E\varepsilon$, is only the ideal tensile stress, that would be necessary to produce the same strain ε. If tensile stress occurred on only two (opposite) faces of the cube (simple tension). We note that q acts on two of the sides of the cube, as well as upon its ends, and that it must be of greater value than f to produce the same change of length in the direction in which f would be applied; because the effect of the q on the sides is to partially counteract the effect of the q on the ends, as regards elongation in the direction of the latter q.

Sincerely yours, I. P. Church.

Ithaca, N. Y., Jan. 12, 1900.

Sir: It is evident from the article on "Stresses in Circular Plates," by Mr. E. Godfrey, published in Engineering News of Jan. 4, that the author of the article is not familiar with the use of the well-known "Poisson's ratio," which is a constant, whose value for any one material depends upon the nature of the material. This constant is denoted by "m" in my "Applied Mechanics," and is often denoted by "$1 \div \mu$" in books on mathematical physics.

Its value for different substances has been the subject of more or less experimental investigation, some ancient and some modern; and, in the light of these experiments, it seems to lie, for most metals between 3 and 4, and the bulk of the experimental evidence locates it, as a rule, nearer 3 than 4.

The value used by Grashof, and in my "Applied Mechanics," in the case of "flat plates" is m = 3, so that, in the case of the circular plate uniformly loaded, and supported all around, equation (26), page 906, viz.:

$$E\varepsilon_o = \frac{3}{8}\,\frac{(m-1)\,(3m+1)}{m^2}\,\frac{pr^2}{h^2}$$

becomes

$$E\varepsilon_o = \frac{5}{6}\,\frac{pr^2}{h^2},$$

and hence

$$\varepsilon_o = \frac{5}{6}\,\frac{pr^2}{Eh^2}$$

is the greatest strain; and, for proper safety, this should be kept within the working strain of the material, which is $\frac{f}{E}$ when f is the working strength per unit area.

Hence, to determine the proper proportions of the plate we have

$$\frac{5}{6}\,\frac{pr^2}{Eh^2} = \frac{f}{E}.$$

From this we readily obtain

$$h = r\sqrt{\frac{5p}{6f}}$$

which is the formula to which Mr. Godfrey objects. He evidently assumes that the value deduced by me for the greatest stress per unit area is

$$\frac{5}{6}\,\frac{pr^2}{h^2},$$

but, in this assumption, he is mistaken, for, while, in the case of simple stress, we can deduce the stress from the strain by multiplying the strain by the modulus of elasticity, it cannot be deduced in this way when, as in the case under discussion, there is a compound stress acting.

If he wants the greatest stress, as deduced from the discussion in the "Applied Mechanics," he has only to multiply the expression for $E\varepsilon_o$ of equation (26) by $\frac{m}{m-1}$, and he will thus obtain for the greatest stress per unit area

$$\sigma_o = \frac{3}{8}\,\frac{3m+1}{m}\,\frac{pr^2}{h^2}, \qquad (1)$$

or, substituting m = 3,

$$\sigma_o = \frac{5}{4}\,\frac{pr^2}{h^2},$$

which is not only larger than $\frac{pr^2}{h^2}$, but also larger than the value $\frac{9}{8}\,\frac{pr^2}{h^2}$, proposed by Mr. Godfrey.

As to the value $\frac{9}{8}\,\frac{pr^2}{h^2}$ it can be readily deduced from equation (1) by substituting $m = \infty$, which is, of course, a value that m never even approaches: Thus equation (1) gives

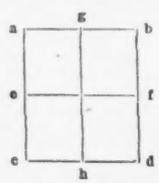
$$\sigma_o = \frac{3}{8}\,\frac{3m+1}{m}\,\frac{pr^2}{h^2} = \frac{3}{8}\,\frac{3+1/m}{1}\,\frac{pr^2}{h^2}$$

and, substituting $m = \infty$, gives

$$\sigma_o = \frac{9}{8}\,\frac{pr^2}{h^2},$$

which is, of course, wrong.

For any one who is familiar with the use of the "Poisson ratio," the above would seem to be a sufficient reply to Mr. Godfrey's remarks; nevertheless, I will add, by way of elementary explanation, that, if we have a square plate of metal a b c d, subjected only to a simple stress in the direction g h, such that the stress per unit area on the section e f, or on any parallel section is equal to σ, and normal to the section e f, then will the strain in the direction g h be $\frac{\sigma}{E}$; but if we apply in addition, a stress in the direction e f, such that the consequent stress per unit area on the section g h, or on any parallel section, is also equal to σ and normal to the section g h, then the strain in either the direction g h, or the direction e f, will be only



$$\varepsilon = \frac{\sigma}{E} - \frac{1}{m}\,\frac{\sigma}{E} = \frac{\sigma}{E}\,\frac{m-1}{m}, \quad \therefore \sigma = \frac{m}{m-1}E\varepsilon$$

Perhaps Mr. Godfrey may think that it is more suitable to so proportion a body that the greatest stress shall not exceed the working strength of the material, instead of so proportioning it that the greatest strain shall not exceed the working strain of the material, because it appears to him that the former method is on the safe side; but, if he will consider any case where the principal stresses are of opposite kinds (as the very usual one of shafting subjected to both bending and twisting) he will find that the former method of procedure will not be on the safe side, but quite the reverse.

I will add that the Rankine formulas for proportioning "Thick Hollow Cylinders" and "Shafting Subjected to Bending and Twisting Combined," are obtained by neglecting all consideration of the Poisson ratio; or, in other words, by assuming $\frac{1}{m} = 0$, which is the same as assuming $m = \infty$.

Gaetano Lanza.

Massachusetts Institute of Technology, Boston, Mass.

Sir: In reply to the criticisms of Professor Lanza and Professor Church, I confess that I did take the value "f" in Lanza's formula to be the actual unit fiber stress on the plate. Without reading all of the 900 pages preceding this formula, I came to the conclusion that, since "f" was called the working strength per square inch, it represented in the formula the actual stress per square inch in the extreme fiber of the plate. Instead, I see that it is an ideal, an imaginary fiber stress, which is intended to represent more accurately the resisting power of the plate in question. What I started out to find was the actual extreme fiber stress at the center of a loaded circular plate, and, if I mistake not, the formula deduced agrees with Prof. Lanza's, when Poisson's ratio is left out of the question.

If Lanza's formula had been given with "f" as the actual fiber stress and a subsequent explanation given, introducing this imaginary fiber stress and the resulting formula, it would give the engineer the choice of accepting, or not, the theory of Poisson's ratio. For my part, I would reject it and choose the first formula, until abundant experiments on flat plates had proved its applicability. No doubt the introduction of this only partially tried theory and the extremely complicated deduction of the formula are responsible for the distrust in which formulæ for flat plates are commonly held.

In Engineering News of Oct. 6, 1898, there is a formula given by Prof C. Bach, deduced from the results of experiments on flat cast-iron cylinder heads, which, when we eliminate the quantities that relate to curvature between flange and head by making the radius of this curve zero, reduces to this form

$$f \geq \frac{3.2\,r^2 p}{h^2},$$

using the nomenclature employed by Prof. Lanza. This is nearly four times the value in Prof. Lanza's formula. Prof. Bach states that the strength of flat heads of cylinders varies, not as the thickness, as D. K. Clark supposed, but as the square of the thickness. All of which indicates the somewhat hazy state of knowledge on the subject.

A few words more in regard to Poisson's ratio and ideal unit stresses. As an example where this might be employed—it is well known that a block of stone will stand more load per unit, if a load P is applied on a unit of area in the center of a large block, than the same material will stand if a small cube of unit cross section is subjected to the load P. At the same time, the compression applied in each case is of the same unit intensity, namely, P. We do not need to have the area multiplied by any ratio in either case to give ideal unit stresses, but take the more easily understood method of suiting the working stress to the case.

It is easy to see how compression on the two opposite faces of a square such as Prof. Lanza gives would, to some extent, counteract compression on the other two faces by the crowding of the material, so to speak; but if the case were tension, it is hard to see how pulling crosswise, on a tensile test piece, for example, would make it harder to break. Again, to make the case analogous to that of the flat plate: Suppose a hub for a wheel of many spokes, all in tension, were to be made of a flat plate; would the engineer be justified in putting only enough metal in a diametrical section to take five-ninths (the ratio of 5-6 to 1½) of the actual stress tending to pull it apart?

If there is anything that Rankine left out that would help to make a formula or its derivation more complicated, I am glad to know it. It is not as bad as it might have been.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Jan. 30, 1900.

Concerning the Surveys and Estimates Made by the New York State Committee on Canals.

Sir: The high esteem which I, in common with all other American engineers, hold your most valuable paper, causes me to regret that your apparent hostility to the improvement of the New York state canals should have led to such statements and such errors concerning the work of the Canal Committee which has just made its report to Governor Roosevelt as appear on the editorial page of your last issue.

You state that the committee worked without any appropriation. This is an error. There was a direct appropriation of $10,000 for use of the committee, and subsequently the balance of an old appropriation, amounting to about $13,000, was transferred for use by the committee. The first appropriation was all expended, but how much of the second was used I do not know.

While the members of the committee itself, with the exception of the State Engineer and Surveyor and Superintendent of Public Works, who are salaried officials, served without pay, engineers and others were employed and paid in collecting the information on which the report was based.

The circumstances were such that the estimates of the cost of the proposed work prepared by the committee are fully as good as could have been made a few years ago at a cost of $100,000 or more. We had the advantage of the Deep Waterways surveys and had the services of Mr. D. J. Howell, one of the principal assistants on this work, who came to us with a wealth of experience gathered along the route of the canal. Mr. George W. Rafter, with a corps of assistants, was employed for several months on the new portion of the proposed canal. He had also been with the Deep Waterways engineers, and came to us with a vast amount of knowledge concerning the canal and the rivers of the state and the water supply questions connected with the canal. Mr. Rafter was

paid for his services, though not as much as he should have received had our appropriation been larger. Mr. Sylvester was paid for his work in estimating the cost of locks.

We had also the advantages of the detailed surveys of the Erie Canal, made during the last few years, which surveys included cross-sections of the canal every hundred feet, and we had the advantages of the detailed and minute knowledge gained by the division engineers and superintendents during their long years of work on the canals. We had also the advantage of the experience gained by the state employees on the $9,000,000 work in 1896-7. Prof. John A. Fairlie, who rendered most valuable aid to the committee in collecting statistics and information and compiling the same, was employed, and received a fair compensation for his services.

It is to be regretted that it has seemed advisable to you to discredit the estimates of the Canal Committee, for I can assure you that they are entitled to full credence, not of course as fully detailed final estimates, but fully enough to be the basis of action by the state. I have much more reason to believe that the work can be completed for less than the estimate than that it will cost more. It has never been a fault of mine to underestimate the cost of work. The great breakwater that I am building at Buffalo will not cost more than 75% of its estimated cost, and this is what could be expected of the Erie Canal enlargement if the work could be thoroughly well managed, and politics be not allowed to dominate it.

I fully agree with you that engineers are not compensated for their services to the extent that they should be, and yet I also believe that there are times and occasions when engineers as well as other citizens can be called upon to give their services to their state or country for patriotic motives. Sometimes even lawyers have been known to do such things.

While the questions before the committee were largely of an engineering nature, there were other features of almost equally as great importance, in the solution of which the non-professional members of the committee gave most valuable services. Yours very truly,

Thomas W. Symons,
Major, Corps of Engineers, U. S. Army.

U. S. Engineer Office, Buffalo, N. Y., March 5, 1900.

Notes and Queries.

The amount of cement-lined service pipe which a gang of six men can prepare in a day at Brookline, Mass., should have been given as 4,000 to 5,000 ft., instead of 400 to 500 ft., on p. 133 of our issue of Feb. 22.

The Mogul tank locomotives for the Dundee & Vryheid Ry., in the Transvaal, illustrated in our last week's issue, were ordered through the firm of Arthur Koppel & Co., 66 Broad St., New York.

Cox & Sons Co., Bridgeton, N. J., inquire concerning the Dick water-seal gas producer illustrated in D. K. Clark's treatise on "Fuel and Its Combustion." They desire to know where and by whom this producer is built, whether it is patented and where it is in practical operation.

REPAIRING STEEL TAPES.

Since publishing the letter of Mr. Aldrich, on repairing steel tapes, in our issue of March 1, we have received a letter from Mr. C. K. Allen, of Mexico, Mo., on the same subject. Mr. Allen also prefers soldered to riveted joints, and uses a thin, narrow strip of copper folded around the broken joint and secured with soft solder. He suggests, for holding the tape while being repaired, a piece of tin or sheet-iron, about 6 ins. long, cut out in the center, leaving two end-pieces about ¾-in. wide. These two ends are turned down over the tape and hold it flat and in line while being repaired. The tools employed are a blow-pipe, some flux and solder, a small flat file, a piece of emery-cloth and a stout pair of scissors; a small flat-nosed pliers will also be useful.

For the flux, take muriatic acid and put into it a small piece of zinc; when the bubbles cease to rise add all the sal-ammoniac that it will dissolve. Clean the break thoroughly with the emery-cloth, moisten it with the flux, and then place a small shaving of the solder upon it and slowly heat with a flame and the blow-pipe until the solder melts and spreads on the tape; and do this to both sides of the tape. While the tape is still hot wipe the solder with a piece of cloth and you will find the tape neatly tinned at the joint. Then take your flat piece of copper and clean one side of it thoroughly with the emery-cloth, and give it a thick coat of tin, as was done with the tape; be sure that the broken ends are in contact; put on the sleeve and place the tape in the clamp and slowly heat with the blow-pipe. When the solder is hot enough to run, clamp the joint with the pliers for a moment, and when cool trim the copper sleeve and polish the joint with the emery-cloth. In using this detail of repair it would also be well to remember the caution of Mr. Aldrich, not to use too wide a sleeve; but to employ a piece of old tape and two sleeves if the break is a long one. Too wide a sleeve interferes with the pliability of the tape.

THE INTEROCEANIC CANAL AND THE HAY-PAUNCEFOTE TREATY.

Hon. John Bassett Moore, Assistant Secretary of State during the Spanish war, and secretary and counsel to the United States Peace Commission at Paris, has contributed to the New York "Times" of March 4 a valuable and exhaustive discussion of the above subject. Mr. Moore is Professor of International Law and Diplomacy in Columbia University, and one of the highest American authorities in this field. We reprint the summary of the results of his investigation and discussion, with which his article concludes, as follows:

Our investigations seem to have shown:

1. That the engagement of neutralization, embodied in the Hay treaty, is amply supported by precedent and by principle.

2. That the policy of a neutralized canal is the historic policy of the United States.

3. That the Clayton-Bulwer treaty, in stipulating for neutralization, excluded either government from constructing and owning the canal, but permitted and required both governments to protect it against all attacks.

4. That this treaty has been repeatedly and continually referred to and acted upon by the United States as a subsisting engagement, and has never in fact been declared to be at an end.

5. That, if the Clayton-Bulwer treaty were abrogated, the situation would not be radically altered, since the neutralization of the canal is guaranteed by various other treaties.

6. That the Hay treaty, while adhering to the policy of neutralization, permits the United States to construct, own and manage the canal, does away with all stipulations for joint intervention, and concedes to the United States alone the liberty to afford protection against lawlessness and disorder.

Into the military question, with which the argument against neutralization is for all practical purposes exclusively concerned, I have not attempted to enter. One view of it is well expressed in the reported statement of Admiral Dewey:

> Fortifications? Why, of course, not. As I understand it, the canal is to be, and should be, a neutralized commercial pathway between the two great oceans. To fortify it would simply result in making it a battleground in case of war. Fortifications would be enormously expensive, and ought not to be erected. Our fleets will be a sufficient guarantee of the neutrality and safety of the canal in time of war, as well as in peace.

In opposition to this weighty opinion of the hero of Manila, it may be urged that circumstances may be conceived in which exclusive military control would, if attainable, constitute a great advantage. This view, however, may suggest the retort that circumstances may readily be conceived in which the assurance of an unobstructed passage would constitute as great an advantage; that, to argue from conceivable circumstances, is in effect to admit that the question is one of chance, and that, in such a predicament, considerations of another order, such as the security and preservation of the canal, the freedom of commerce and navigation, and that "decent respect to the opinions of mankind," of which the Declaration of Independence speaks, should prove decisive.

DETAILED SURVEYS FOR ERIE CANAL ENLARGEMENT are provided for by a bill introduced in the New York Assembly on March 6. The sum of $200,000 is appropriated and the work is to be done under direction of the State Engineer. The alternative routes recommended by the Governor's Advisory Committee are to be examined and the estimates are to be for a barge canal with 12 ft. minimum depth of water except in locks and over structures, to accommodate boats of 1,000 tons cargo capacity. The surveys are to be completed and the results reported by Jan. 1, 1901. It is generally agreed that no appropriation for canal enlargement will be made at the present session of the legislature.

DEFECTIVE PAVING IN CHICAGO has been brought to light in one case through the complaint of the alderman in the ward in which the work was done. This particular case is on West Lake St., where brick paving on concrete foundation was laid some months ago. Many complaints and rumors of defective work were circulated, but were quieted in some way until Mr. Fowler persisted in forcing an investigation by the Civil Service Commission. Some of the evidence presented and published was extremely interesting, showing among other things how rejected cement was used in large quantities. As a result, some of the inspectors on the work have been discharged from the service. It is said that the contractors will not be paid and that steps will be taken by the Street Department to prevent a recurrence of such work. The report recommends that no engineers or inspectors be allowed to make deviations from any specifications without permission from the Board of Review, and that such permission be recorded in the minutes of the board. The findings of the commission, in detail, are as follows:

The work was not completed by Oct. 31, as required, and the contractors are liable to forfeit $25 a day from that date until Dec. 4.

The subgrade is practically all right.

The curb wall was not plastered to a depth of 5 ft., as required, but only 2½ to 3 ft.

No real complaint can be found with the top dressing.

The concrete foundation was not of a uniform depth of 6 ins., as required, but an average of 5.2 ins.

Much of the cement used had been rejected by the tester, and much was used which had not been passed upon.

In a large portion of the work crushed stone was used instead of torpedo sand, as required.

Brick used was not tested as required, and much put in has already chipped.

The crosswalks at street intersections do not correspond with the specifications.

There are no crosswalks in the middle of blocks, although provided for in the specifications.

In the mixture of concrete the proper amount of cement was not used and that used was not Portland, but a cement from 15 to 20% cheaper.

The manholes and catch-basins are not properly set.

AN APPARATUS FOR RECORDING AUTOMATICALLY the depth of flow in the 34×51-in. egg-shaped outlet sewer at Waltham, Mass., is being installed, according to plans and under the direction of the city engineer, Mr. Bertram Brewer. It is intended to keep a constant record of the amount of sewage contributed by the city to the Metropolitan sewerage system. A chamber, 5×8 ft. in plan, with concrete walls and roof, is being constructed in the sewer. In a suitable compartment, so connected with the flow of sewage as to be sensitive to the slightest change, a float will be placed. This float will be connected by pulleys with a transmitter which will electrically record the changes in elevation of the flow of sewage. All the sensitive recording features of the apparatus will be placed in a dry room in a house about three-quarters of a mile distant from the sewer. The record has a range of 4 ft., and will be made on a roll of profile paper with a vertical scale of 1 ft. per in. and a horizontal scale of 6 hours per in. Each roll will contain seven days' record. The apparatus selected is a modification of the device patented on Jan. 8, 1889, by Mr. George E. Winslow, of Waltham, Mass., and used since then by a number of water-works to electrically indicate and record the level of water in reservoirs and stand-pipes. The sewer will be carefully rated by a set of weir gagings to accurately determine the volume of flow for the depths recorded. The city of Waltham has a separate system of sewers. The population of the city at the present time is estimated at 22,500, of which 20,000 are now contributing sewage to the sewer system. We are indebted to Mr. Brewer for much of the information given. It is only fair to him and our readers to state that it will be some months before results of the gagings can be expected.

THE ADULTERATION OF FOOD AND DRINK was submitted to a committee of the U. S. Senate to investigate the charges made that this adulteration is sometimes so great as to be detrimental to health, or a fraud upon the purchaser. The committee has heard much testimony and finds that this adulteration is extensively practiced, especially in pepper, cinnamon, cloves and spices generally; as much as 60% ground cocoanut shells being found in some of them. Two plans have been suggested to correct this evil. One is to put all important food products under the internal revenue law, as is now the case with butter, filled cheese and flour. The other plan is contained in Senate bill 2,426, which proposes to establish a department under the Secretary of Agriculture, and provides for the establishment of a board which shall fix the standard of purity of these products, and prescribes penalties for infractions of the regulations established. The latter plan is less cumbersome than the first and is favored. Such action would destroy that kind of competition in trade which is resulting in adulterated food and drink.

THE NEW YORK STATE COLLEGE OF FORESTRY, at Ithica, reports, in Bulletin No. 2, that it now has 17 students inscribed, and 30 other students are taking some of the courses. The college forests are reported upon in full. These were purchased by the trustees of Cornell University for $165,000, and are located near Tupper and Saranac lakes. This land is all surveyed, subdivided, etc., and a beginning has been made in planting waste and burned spaces; two nurseries for pine and spruce are established, with over one million seedlings.

FALSEWORK FOR ERECTING THE MANHATTAN TOWERS AND END SPANS, NEW EAST RIVER BRIDGE.

(With two-page plate.)

By C. E. Fowler, M. Am. Soc. C. E.*

The new East River Bridge, which is being constructed from near the foot of Delancey St., Manhattan, to near the foot of South Sixth St., Brooklyn, will have steel towers from a point 20 ft. above mean high water, and, unlike the old Brooklyn Bridge, which has the back stays loaded, it will have steel approach spans entirely unsupported by the cables. The first span, from the anchorage to the intermediate steel tower, has a pin center length of 296 ft. 4⅞ ins., with a cantilever arm extending towards the main tower 59 ft. 3¾ ins., and supporting one end of the tower or suspended span, making a total distance of 300 ft. 1⅛ ins. from the center of the intermediate tower to the center of the main tower.

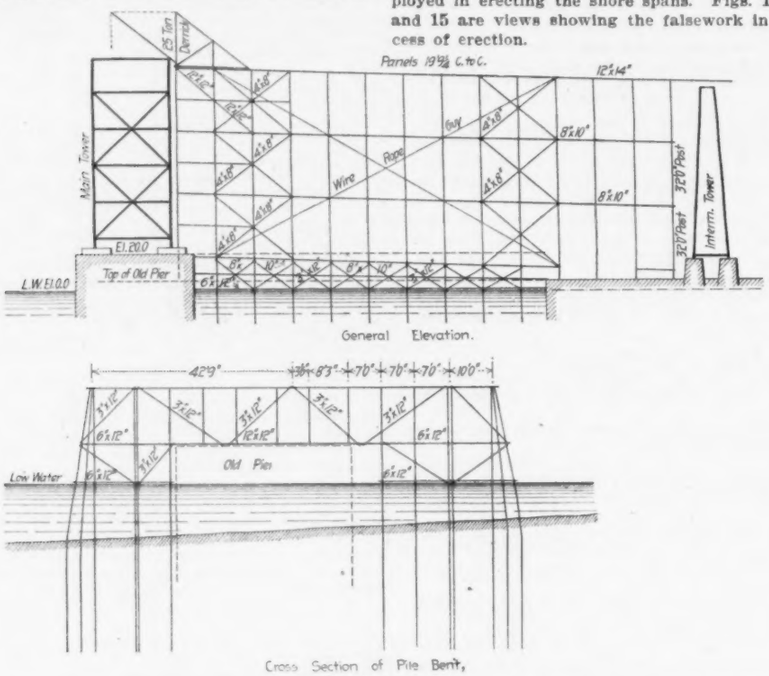


FIG. 1.—GENERAL ELEVATION OF FALSEWORKS, SHOWING TRANSVERSE SECTION OF PILE-SUPPORTING BENTS.

The intermediate tower, 93 ft. 9⅝ ins. in height, consists of two separate towers of four columns each, connected together at the top by cross girders and arched bracing. The main towers consist of eight steel columns braced together in all directions, with cross girders at the floor level to support the end spans indirectly, the roadway and the stiffening trusses. Above this system of heavy girders are heavy double box portals surmounted by double X-bracing to the top of the towers, where there are other heavy girders to carry the rollers and saddles for the support of the cables. Each post is of a closed box section 4 ft. square, the bottom panel being battered, and made up of two ⅞-in. and two ¾-in. web plates, four ⅞-in. cover plates, four 8 × 6 × ¾-in. angles, and eight diaphragms of four 3½ × 3½ × ½-in. angles, with ½-in. web plates. This section of the column, weighing about 24 tons, has a base plate 96 ins. × 1 in.—8 ft., and rests directly upon the cast steel base 3 ft. 6 ins. in height.

The contract for the manufacture and erection of the four approach spans, intermediate and main towers was let to the New Jersey Steel & Iron Co., of Trenton, N. J., who sublet the erection of the work at the Manhattan end to the Terry & Tench Construction Co., 11 Broadway, New York city.

Referring to the illustrations, Fig. 1 is a general elevation of the falseworks showing a transverse section of the pile supporting bents. Fig. 2 shows the special bent construction over the tower masonry, and Fig. 3 shows the normal bent construction between towers. Fig. 4 shows a side and an end elevation of the derrick lighter, and Figs. 5 and 6 are enlarged details of the derrick proper. Fig. 7 gives the general details of the timber tower for erecting the main steel towers; and Fig. 8 is a diagram side elevation of this timber tower. Fig. 9 shows a typical connection detail of the timber tower. Fig. 10 gives the details of the special 25-ton hoisting blocks. Figs. 11 and 12 are, respectively, side and end elevations of the traveler employed in erecting the shore spans. Figs. 13, 14 and 15 are views showing the falsework in process of erection.

The great height of the towers, 309 ft. 8½ ins. from the top of the masonry to the center of the cables, or practically 333 ft. above the river; the weight of the tower sections and of the cast steel saddles which weigh about 35 tons each and which must be raised to the extreme top of the towers; the height of falsework required for the spans, 120 ft. above mean high water; the width of the spans, 67 ft. c. to c. of trusses and 118 ft. extreme; and the heavy character of the spans, together with the fact that they are of multiple lattice design, all served to make the arrangements for the erection quite unusual and of great interest.

The falsework at the Manhattan end consists of practically two separate trestles, three stories in height, each having four 12 × 12-in. plumb posts, two 12 × 12-in. batters and caps 12 × 12 ins. common to both, as are also the 4 × 8-in. diagonal braces, which are single bolted at all intersections with ¾-in. screw bolts, except near the ends, where double bolts are used. The diagonals are lap-spliced with four ¾-in. bolts, the caps butted with timber splice pieces bolted through, while the 3 × 12-in. scabs are single bolted except near the feet of the diagonals, where double bolts are used.

The old dock, which extends out between the granite pedestals, is founded partly on piles and partly on rock-filled cribs; this was incorporated in the falsework, carrying nearly one-half the width on jack bents, the balance being carried on 65-ft. piles driven firmly into the river bed, through a depth of water varying from 8 to 15 ft. Where the piles drove solidly they were stopped at the bottom of the falsework, but in many cases where the bottom was soft they were driven down to the level of the dock and where the bottom was very soft double piles were driven. These piles were firmly braced with timber diagonals, tied to the old dock, and the longitudinal ties were cut in between the old bulkhead and the stone pedestals.

The specifications require that the end of the suspended span at the tower, which will eventually rest on the stiffening trusses, shall have a support provided on the falsework until such time as the stiffening trusses are in place. This necessitated the design of a special pier bent, which has, just beneath and outside each truss, four plumb posts, 12 × 12 ins., 3 ft. apart on centers, there being also bracing back to the adjacent regular bent to half-length them. Double batters, 12 × 12 ins., extend out to the outside of the stonework and in to the center of the bent, there being also five intermediate plumb posts supporting the caps, while the diagonal bracing consists of double 4 × 8-in. pieces, double bolted at each main plumb post. The two main inside plumb posts at each side carry the truss weight during erection, while the outside pairs carry 25-ton derricks, which are used to erect the main towers. When it is desired to carry the entire reaction from the suspended span, additional plumb posts will be added at each side.

The falsework is braced longitudinally by 8 × 12-in. stringpieces at each main plump post, four lines to each story, by the 12 × 14-in. stringers on the top, and by diagonal longitudinal bracing. This consists of two towers, with 4 × 8-in. diagonals extending over two panels and in four planes, one at each main plumb post transversely, and ⅞-in. wire rope guys extending lengthwise from braced tower to braced tower.

The falsework was all framed to figured dimensions, the bolt holes all bored in posts and diagonals, then bolted together in sections of one-story

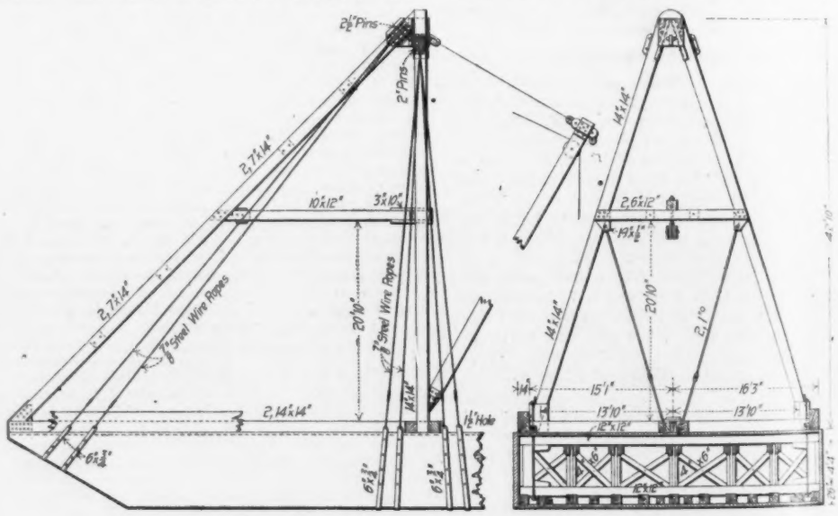


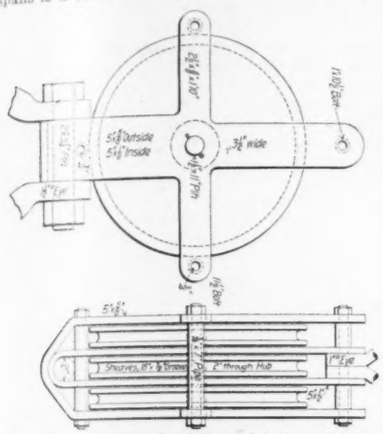
FIG. 4.—SHEAR LEG LIGHTER DERRICK.

*Consulting Engineer for the Terry & Tench Construction Co., 11 Broadway, New York city.

each and laid along the line of the work, one section overlapping another.

When the two bents next the pier had been erected by means of a derrick on the masonry, and by tripping them up, double traveling derricks were erected on top with reach enough to pick up the sections and set them in place, one panel ahead, after which the derricks were moved ahead ready to place another bent.

The traveler for handling the steelwork of the spans is a three-bent one, with 12 × 12-in. posts,


3½" wide
5½" Inside
5½" Inside
1½" Bolt
1½" Bolt
1½" Bolt

second story, diagonally downwards to the opposite outside corner post of the main steel tower. The erection of the wooden tower is being accomplished by the use of a 70-ft. high gallows frame of two 10 × 10-in. posts, with sill, cap and bracing. Its position when raising one side of the second story is shown by the dotted lines, and when this story is up, falls are attached to the gallows frame about the height of the first story tower cap and to the tower cap above, so that the gallows frame is hoisted up a story ready to place an additional section. The stiff legs of the derricks on top of the tower will be anchored to the steelwork below by 1⅝-in. galvanized cables, to take up the reaction as the heavy column sections are raised. As the steel tower is completed, a story at a time, the wooden tower will be attached to it. The raising of the 35-ton saddle castings will be done by the use of a short heavy gallows frame set on top of the wooden tower, and carrying heavy steel falls.

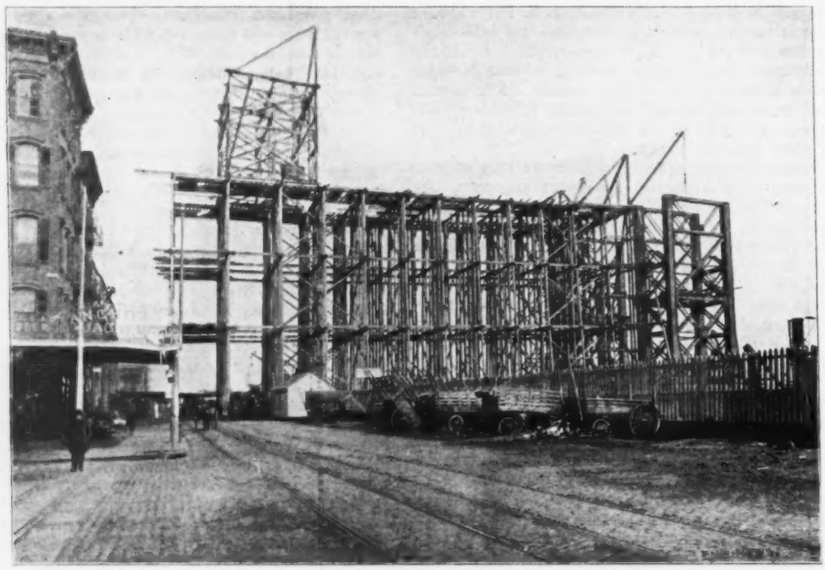


FIG. 14.—SIDE VIEW OF FALSEWORKS LOOKING NORTH WITH TRAVELER, SHOWING STEEL TOWER PARTLY ERECTED.

The steel of which the bridge is being constructed is acid open-hearth throughout, with less than 0.1% of silicon, less than 0.08% of phosphorus, less than 0.03% of sulphur, and less than 0.50% of manganese. The steel in plates and shapes has an ultimate strength of from 60,000 to 68,000 lbs. per sq. in., elastic limit of not less than 33,000 lbs. per sq. in., and an elongation of not less than 20% in 8 ins. The rivet steel has an ultimate strength of from 47,000 to 56,000 lbs. per sq. in., an elastic limit of not less than 30,000 lbs. per sq. in., and an elongation of not less than 25% in 8 ins.

The specifications require machine riveting in the field wherever practicable, and as the rivets are ⅞-in. and 1-in. in diameter, and as each joint has numerous rivets, a quite extensive plant has been provided. In addition to two hoisting engine boilers which are available to furnish steam for a compressor, an additional 30-HP. boiler has been provided. The compressor is a Clayton duplex machine, set in back of the boilers, with a capacity of 172 ft. of free air per minute. The air pressure will be kept at 100 lbs., there being three receivers 16 × 54 ins. and a pipe 1½ ins. in diameter, running the whole length of the work, which will also act as a receiver. The riveting will all be done by the use of Boyer percussion riveters, of the "long gun" type. There will be six of them available for use at one time, with a total capacity of from 2,000 to 4,000 rivets per day. Arrangements are also made to provide air blast for blowing the rivet heating forges if it is desired.

The 30-HP. hoisting engine boilers which will be used for furnishing a portion of the steam to the compressor, are those of the engines which serve the 25-ton derricks. They are of special build with 10 × 10-in. double cylinders, while they have double drums for the wire rope and two spools, one on each drum shaft, to handle runner or fall lines as desired.

The general layout of the falseworks and erecting plant was made by Mr. Edward F. Terry, of the Terry & Tench Construction Co., and the writer acted as consulting engineer on the design and construction of the work.

RAILWAY MAINTENANCE OF WAY EXPENSES.

The advocates of reform in railway track construction, in the way of a more permanent character of work, have very frequently called attention to the fact that under the present system the maintenance charges are extremely high. From official statements and from the annual reports of railway companies we have prepared the following table, showing the relation of the maintenance of way expenses to the mileage, train mileage and operating expenses, on a number of railways. In most cases where figures of this kind have been used in discussions they are given for "maintenance of way and structures," but the expenditures on structures vary within very wide limits, according to the character and number of structures, and these expenses cannot be reduced to any common or uniform basis for comparison. Under such conditions, the total expenditures on way and structures give but little idea as to the comparative expenses for maintenance of way on different roads. In the figures given in the following table, we have taken the expenditures for maintenance of way proper (including general work on roadway, rail and tie renewals, and ballasting) and show their relation to the operating expenses and train mileage. In a few cases this cannot be done, the railways stating that they are unable to separate the expenditures on maintenance of way proper. Most of the figures are for the fiscal years ending in 1899, but some are for the year 1898.

From the columns showing the cost of maintenance of way, it will be seen that the expenses range from $546 to $1,463 per mile of road; from 6.76 to 24.4 cts. per revenue train mile, and from 6.50% to 21.7% of the operating expenses. The columns giving the cost of maintenance of way and structures show that these expenses range from $490 to $3,264 per mile of road, from 15 to 34.2 cts. per revenue train mile, and from 15.6% to 32% of the operating expenses.

At the end of the table are given similar figures for five of the leading English railways, and these make a rather interesting comparison with the figures for American railways. The maintenance of way expenses of the former, approximate to a low average of those of the latter when taken per mile of road, but are materially lower per train-mile and form a considerably smaller percentage of the operating expenses. From this it will be seen that the English railways with their almost universally substantial track construction, are operated more economically in regard to this branch of the expenditures, but if the varying character of track on the American roads could be classified it would probably be seen that the maintenance of way expenses on first-class American track would be pretty close to that of the English roads. When we come to "maintenance of way and structures," however, the expenses per mile and the percentage of these expenses to the total operating expenses come closer to the results obtained on American roads, although the expenses per train-mile are much lower. As to the percentage of operating expenses to gross earnings, there is not such a marked difference as is usually supposed. In fact, we believe that English railway men would be somewhat sur-

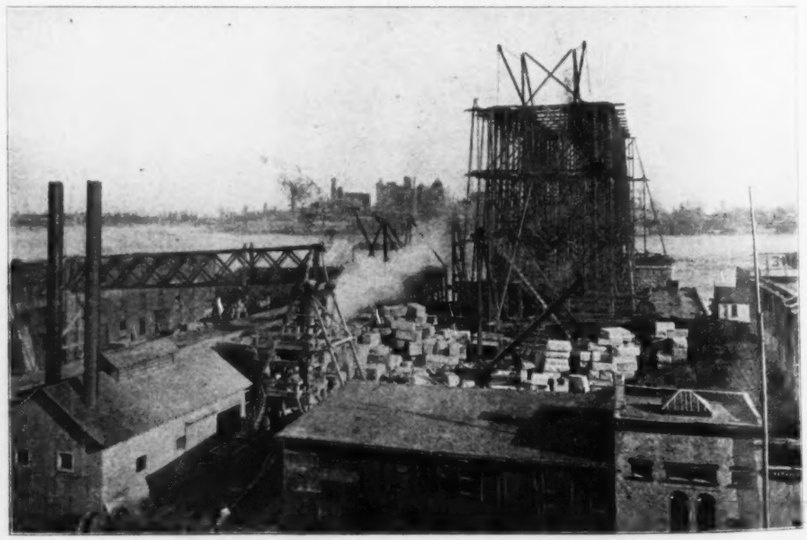


FIG. 15.—END VIEW OF FALSEWORKS LOOKING ACROSS EAST RIVER.

Railway Maintenance-of-Way Expenses.

Railways.	No. miles.	Ratio of operating exp. to grs. earngs, per ct.	Cost of Maintenance of way. Per mile.	Per train-mile, cts.	Per ct. of op. ex. per ct.	M. of way & structures. Per mile.	Per train-mile, cts.	Per ct. of op. ex. per ct.
Maine Central	823	65.38	$696	17.6	17.4	$861	21.8	21.6
Fitchburg	825	69.00	1,340	11.3	11.5	2,058	17.7	17.7
New York, New Haven & Hartford.	2,047	68.87	1,799	18.8	14.4	2,427	25.5	19.4
New York Central	2,395	63.07	1,463	11.8	12.0	1,963	15.8	16.0
Erie	2,270	74.57	976	9.4	8.8	1,358	13.1	12.2
Lake Shore & Michigan Southern..	1,413	67.11	1,106	10.0	11.2	1,632	18.3	16.5
Michigan Central	1,658	72.25	787	....	13.0	1,190	....	19.4
Pennsylvania R. R.*	2,190	68.00	...	....	....	3,264	....	18.0
Pennsylvania Lines	2,554	70.70	678	6.76	6.50	1,961	19.0	19.0
Lake Erie & Western	725	57.76	389	12.0	14.0	475	15.0	17.0
Chicago & Northwestern	5,077	62.23	659	12.8	14.15	932	18.0	20.0
Chicago, Burlington & Quincy....	7,419	64.84	591	14.7	16.5	852	21.13	23.8
Chicago, Milwaukee & St. Paul....	6,154	62.55	582	14.5	15.0	829	20.07	21.3
Chicago, Rock Island & Pacific....	3,619	61.75	642	15.9	18.2	898	22.3	25.4
Illinois Central	3,679	64.70	633	10.8	13.2	1,164	19.0	23.5
Iowa Central	513	70.53	...	....	....	938	26.0	32.0
Missouri, Kansas & Texas	2,200	67.00	....	....	....	601	15.6	15.6
International & Great Northern...	825	71.04	562	18.0	16.0	849	28.0	24.0
Atchison, Topeka & Santa Fe.....	7,108	68.14	750	19.6	19.3	1,079	28.0	28.0
Northern Pacific	4,635	47.40	546	24.4	21.7	765	34.2	28.7
Great Northern	4,787	48.62	...	....	....	727	34.2	28.6
Canadian Pacific	6,081	59.92	344	13.0	14.7	490	18.5	21.0
		English Railways.						
Great Eastern	1,044	59.79	680	6.4	9.6	965	9.0	13.6
Great Western	2,599	62.21	735	8.2	12.0	1,355	15.4	22.4
Lancashire & Yorkshire	558	54.00	720	4.2	6.0	2,350	14.0	18.8
London & Northwestern	1,908	58.40	695	5.4	7.0	1,510	11.8	15.0
Midland	1,480	58.90	980	5.0	9.0	1,660	9.4	15.0

*Pennsylvania and New Jersey Divisions only.

prised to find that the percentage on American railways averages but little higher than that on English railways, instead of representing a great proportion of the earnings.

THE COMPUTATION OF CONCRETE FOOTINGS FOR WALLS AND COLUMNS.

A correspondent, in our issue of Oct. 19, 1899, called attention to the lack of information concerning the computation of concrete footings for walls and columns, and presented for criticism an approximate method which he had employed in lieu of a better one. In this connection the following abstract of an article on this subject, written by Mr. Geo. H. Blagrove for the "Contract Journal," of London, England, will be of interest:

Loads upon Walls and Foundations.—In order to estimate the extent of concrete required beneath a wall, we must first know the load which the wall will have to carry, including its own weight, and then the bearing power of the soil. Ordinary brickwork will rarely carry more than about 6 tons per sq. ft. of sectional area, taken just above the footings; and experiments have shown that stock brickwork may commence cracking before the limit is reached. The greatest load upon brickwork will probably not exceed 10 tons per sq. ft. upon blue Staffordshire bricks built in cement mortar, while the load upon masonry will probably not exceed 16 tons per sq. ft.

The bearing power of a soil is indicated by the load which can be placed upon it, without perceptible sinking. Stiff blue clay or coarse gravel will bear as much as four to five tons per square foot, while soft clay will seldom bear more than two tons, and loamy earth less than this. Assuming this latter as the limiting bearing power of an ordinary soil, we see that when a wall is loaded to the extent of 6 tons per sq. ft., the concrete beneath it must extend to three times the thickness of the wall. When this is so, the wall can only sink by fracturing the concrete transversely. The concrete must therefore be thick enough to resist the transverse strain that will come upon it. This transverse strain will be due to the upward reaction of the earth upon that portion of the concrete which is not kept down by the load above. In calculating this strain we cannot assume that the load upon the wall is distributed over the base of the footings, because, if the concrete were to break, there would be a possibility of the footings turning up. The strength of brick footings depends mainly upon the adhesive force of the mortar in them; and in all theoretical calculations of stability in structures it is customary to neglect this adhesive force, the assumption being that every structure is so designed that it would stand if built dry.

Assuming, then, the case of an 18-in. brick wall, loaded to the extent of 6 tons per sq. ft. of sectional area, this would give, for a section of wall 1 ft. in length, a load of 9 tons. Assuming that the soil will not bear more than 2 tons per sq. ft., then the soil immediately under this portion of the wall will bear 3 tons, and the remaining 6 tons must be transferred to the earth by means of a bed of concrete extending to 18 ins. on each side of the wall, or to a total width of 4 ft. 6 ins. The transverse strain upon this concrete will be equivalent to that upon two beams, each 12 ins. wide, fixed at one end, projecting 18 ins., and loaded uniformly with three tons each; or it will be equivalent to the strain produced by an evenly distributed load of 6 tons upon one such beam, over a clear span of 3 ft., the ends being supported.

Transverse Strength of Concrete.—Some instructive experiments were tried some years ago at the Colombo Harbor Works, Ceylon, by Mr. John Kyle. Concrete blocks or bars, 4 ft. long, by 12 ins. square, were broken by hydraulic pressure centrally applied over a clear span of 3 ft. The ingredients of the concrete were varied, but we shall refer only to those experiments in which it was composed with 1 part by weight of good Portland cement and 8 of other materials—sand and broken stone or river gravel. These are the proportions prescribed for cement concrete in the bylaws of the London County Council, and such concrete is presumably equal in strength to that composed with 1 part of lime and 6 of other materials.

In 9 experiments under the conditions mentioned, the breaking weight varied from 3,640 to 7,560 lbs. Taking the lower of these two values, expressed in tons, we have 1.625 for the central breaking weight. By the usual formula for beams,

$$W = \frac{b\ d^2\ K}{l},$$

where W is the breaking weight in tons, b is the breadth, d the depth, and l the unsupported length in inches, and K is a coefficient of ultimate resistance. In this case, we have

$$1.625 = \frac{(12 \times 12^2)\ K}{36} = 48\ K,$$

whence

$$K = \frac{1.625}{48} = .0338.$$

For a distributed load we should employ 2 K = .0676, and for safe working loads, in practice we require a coefficient, K′, equal to one-third of 2 K, or

$$\frac{.0676}{3} = .0225.$$

Applying our formula now to the case assumed above, where the safe distributed load is 6 tons, the span 3 ft., the breadth of the beam 12 ins., while the depth is required to be known, we have,

$$6 = \frac{(.0225 \times 12)\ d^2}{36} = .0075\ d^2,$$

whence

$$d^2 = \frac{6}{.0075} = 800, \text{ and } d = \sqrt{800} = 28.28,$$

for the depth in inches of our concrete, which may therefore be stated at 2 ft. 6 ins. If the load upon the brickwork were 12 tons instead of 6 tons per sq. ft., and if the soil were capable of bearing 4 tons per sq. ft., we should require only the same extent of concrete—viz., 18 ins. projection on each side of an 18-in. wall; but its transverse resistance would have to be doubled, and as this varies with the square of the depth, it would be sufficient to increase the latter in the ratio of 1 to $\sqrt{2}$, or, say, multiply the depth by 1.4, which would give $28.28 \times 1.4 = 39.59$, or, say, 3 ft. 4 ins. for the depth. It may be noted that, for all ordinary cases, the projection on each side need not exceed the thickness of the wall, the depth being about two-thirds of the total width.

Concrete Under Iron Columns.—The greatest concentrated loads are generally those upon iron columns or stancheons. In such cases many people prefer not to employ a base-stone, owing to the possibility of some unseen defect in the stone, which might cause it to crack under the great pressure to which it would be subjected. The surface of the concrete may therefore be floated with neat Portland cement, and the base of the column placed directly upon it. Clearly, the base of the column must be large enough to distribute the weight over a sufficent surface of concrete, so that the latter be subjected to no undue pressure. A safe limit is 20 tons per sq. ft.; and if we assume that the base of a column 12 ins. square transmits a pressure of 20 tons to a bed of concrete, and that the latter rests upon a soil that will not safely bear more than 2 tons per sq. ft., it is evident that the concrete must extend over 10 sq. ft., or it may measure 3 ft. 4 ins. by 3 ft. 4 ins.

In finding the required depth of the concrete, the problem is somewhat complicated through the concrete extending in all four directions from the load; but an approximate calculation gives the depth required as 2 ft. 6 ins.; whence it may be inferred that the depth of concrete under iron columns or stanchions should not be less than three-fourths of its width.

A TRANSFORMER FOR FURNISHING LARGE CURRENTS.

Among the new industries which have been located at Niagara Falls, on account of the cheap water power there available, are the manufacture of carborundum and of artificial graphite. In both cases the process consists in heating a conducting body to a high temperature by passing an electric current through it.

In the manufacture of carborundum a mixture of ground coke and sand, with a flux of common salt, is placed between large carbon electrodes which are connected to the terminals of a low-voltage transformer. A current of large magnitude is allowed to flow until the mass reaches an extremely high temperature, probably the highest obtained by any means at man's control. The non-conducting covering of sand and sawdust is afterwards removed and the hot core is allowed to cool. It is then broken up, but it consists no longer of coke and sand. The carbon and silicon have combined to form crystals of silicon carbide, or carborundum.

It was soon discovered in the manufacture of carborundum that by practically the same process coke could be converted into graphite. A factory for the manufacture of graphite was accordingly built adjoining the works of the Carborundum Co. It is under the control of the Acheson Graphite Co., founded by Mr. E. G. Acheson, who also founded the Carborundum Co.

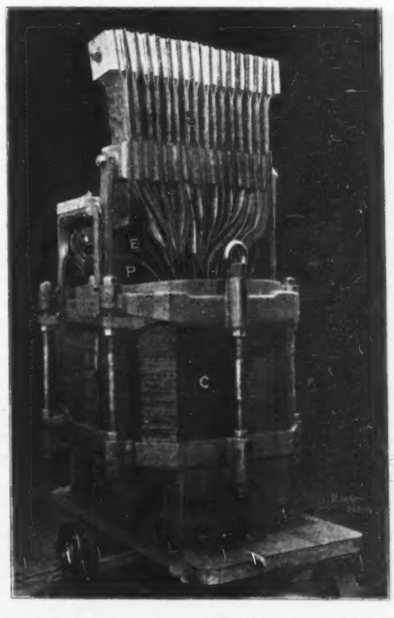


Fig. 1.—Transformer for Furnishing Large Currents. Made by the Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

As stated above, a very large current is required to heat the conducting mass, which, because of its size and the materials composing it, has comparatively low resistance. Also on account of the latter fact, only a low voltage is necessary. As the resistance of the body under treatment varies greatly with the temperature, and because of chemical and other changes, the voltage must be variable at will to provide for effective control of the current. These conditions have been met by the construction of special transformers. A

transformer of about 450 K-W. capacity, built for the Acheson Graphite Co., is illustrated in the accompanying illustrations.

Current is received from the Niagara Power Co. at 2,200 volts. The voltage at the secondary terminals may be varied from 12 to 30. At 12 volts the maximum permissible current is 37,500 amperes. The secondary winding consists of a single turn of heavy copper bars, which run out through the top of the transformer case to heavy leads

Fig. 2.—Transformer Case.

going to the switchboard. The copper bars forming the secondary are eight in number. The 16 ends or terminals of these bars are arranged in a row with the negative and positive ends alternating, as may be seen at S, Fig. 1. This arrangement is adhered to in the conductors leading to the switchboard and from there to the furnace. Its object is to reduce self-induction which, with such large currents, might otherwise give rise to a low power-factor in the supply circuit. In spite of the large area open to inductive action at the furnace, the power-factor in the present case has been raised to about 85%.

All alterations of pressure are carried on in the primary winding, since the secondary circuit is not designed for changes of connections. The delivered voltage is varied by changing the number of primary turns in series across the 2,200-volt line, this variation changing the E. M. F. per turn within the transformer by changing the density of the alternating magnetic field set up in the iron core. The voltage set up in the one secondary turn is varied proportionally by this change of density in the iron core. The variation of the number of primary turns is made without any interruption of the circuit, by means of switches and of a very simple arrangement of resistances.

A view of the switchboard is shown in Fig. 3. Upon it are mounted 20 switches, corresponding with the number of steps from maximum to minimum turns in the primary, eleven of these being running steps on which the transformer may be worked for any length of time, and the other nine being merely intermediate, change-over steps connected through resistances which are not designed to carry the load permanently. Should any one of the running switches be closed, the incoming line is connected directly into the transformer winding at a point dependent upon the switch closed. The resistances used are sufficient with the normal primary current of 240 amperes, which usually does not vary, to cause a drop equal to about half the drop between any two consecutive running switches. The swiches are of a quick-break type, and are separated from each other by slabs of marble. They are not fitted with handles, but are designed with holes in which a hook on the end of a wooden pole may be inserted. The resistances used are of an iron-clad type, similar to those used on street cars, and sometimes called "diverters."

The primary and secondary coils are thoroughly insulated from each other by layers of enamelled paper, to be seen at E, Fig. 1. One of the primary coils is shown at P. Further insulation is secured by a bath of oil. The oil also serves to cool the windings, and the iron core C. The oil itself is cooled by a system of cold-water pipes. The entire apparatus is enclosed in a circular tank, 6 ft. high and 64 ins. in diameter.

We are indebted to the manufacturers of this device, the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., for the illustrations and for information used in preparing the foregoing article.

BOOK REVIEWS.

KINEMATICS OF MACHINERY.—A brief treatise on Constrained Motions of Machine Elements. By John H. Barr, M. S., M. M. E., Professor of Machine Design, Sibley College, Cornell University. New York: John Wiley & Sons; London: Chapman & Hall, Ltd. 8vo.; cloth; pp. 247; 213 figures; $2.50.

The object and scope of this work is given in the following extract from the preface:

The present volume was prepared especially to bring together, and to present to the students in a condensed text-book, those principles and methods which are deemed most important in a general course on Kinematics. This is the only excuse offered for another book on a subject about which so much has been written. No pretension is made to originality except in the arrangement and manner of presenting a few subjects. Neither is the present work offered as in any sense a complete treatise on the Kinematics of Machinery. The treatment of many topics has been much abridged; particularly the portion relating to toothed gearing, a subject which is exhaustively treated in numerous available works. On the other hand, the discussions of the applications of such important conceptions as instantaneous centers, velocity diagrams, etc., are rather fuller than are found in many of the shorter works on Mechanism.

The treatment of these subjects follows closely that given by Professor Kennedy in his admirable work on the "Mechanics of Machinery."

It is believed that the presentation of principles and methods, with illustrations of their applications, is the proper line to adopt in a text-book intended for a short general course on such a subject as Kinematics. The detailed description of usual forms, and the discussion of the innumerable considerations with which the expert in any line must be familiar are to be sought in special treatises.

Prof. Barr's book is one of the best works on Kinematics, for the use of students in technical schools, that has come under our notice. The author seems to have had in mind the fact that the amount of time which a student can give to the subject is necessarily short, and that therefore a book for his purpose should be brief, its language clear, concise and exact, and the cases selected for treatment those that have some relation to mechanism commonly used in practice rather than those that are interesting as curiosities or that are valuable as exercises in mental gymnastics. The amount of hard study now required of the students in higher mathematics, in descriptive geometry and in theoretical mechanics, is so great that it is much to be desired that kinematics be made shorter and easier for him than it is in the formidable treatises of Willis and other early writers. While the work is a brief one, it appears to be sufficiently thorough as far as it goes, and many references are given to other works where the student may find fuller information on different branches of the subject. A valuable feature is an appendix containing 61 exercises and problems to be solved by students. These are mostly of a practical character.

THE RUSSIAN JOURNAL OF FINANCIAL STATISTICS. 1900.—St. Petersburg, Russia: W. Kirshbaum, Publisher. Printed in English. Paper; 10½ × 6¾ ins.; pp. 236. Quarterly, $5 per year.

This somewhat peculiar publication is intended to correct current ideas regarding Russian finance, industrial conditions and state enterprises. The preface points out the blunders constantly made by those unfamiliar with Russian conditions and units of expression, and shows the unreliable character of many of the sources of information used by foreigners and the conflicting nature of statistics as employed by these strangers. It points out the fact that while Russia is far behind England in wealth and America in productiveness, and in accumulated wealth is behind France and Germany in addition, Russia is yet "the greatest economic unit on the face of the globe." This is due to the unique character of the assets of the Russian State. As a landowner, says the editor, it draws an annual net profit of 45,000,000 roubles from its forests, mines and agricultural property; from the lands purchased for its communities of ex-serfs, it draws over 80,000,000 roubles per year; as a builder and operator of railways it controls a system of 20,300 miles and takes from this property an annual net profit of $70,000,000, or about one-seventh of the net revenue of all the American railways. The Russian State is a capitalist banker, metallurgist and spirit merchant; and apart from its banking operations, the State Treasury, in 1898, received over $900,000,000, of which nearly $400,000,000 did not come from taxation of any kind. This is claimed to be a budget of which any state might be envious; and it outstrips that of France by $200,000,000. The annual charge for the capital and interest of the Russian national debt—which is nearly equal in capital to the English national debt, is about $145,000,000. About one-half of this debt is placed abroad, and all of it is practically in the form of bonds payable to bearer, with quarterly coupons attached, which are paid in the currency of the country of the holder of the bonds at mint rates of exchange.

The contents of the present number relate to the production of gold in Russia—which is rapidly declining; the revenue from the state monopoly on spirits, which, in 1894, was $161,250, from a population of 122,500,000 inhabitants; the Russian system of weights and measures fully explained; the coinage law of 1899; the profits and all details of joint-stock mining and banking companies, January to July, 1899; Russian-British conversion tables of weights and measures; conversion tables of British and American money; the Russian national debt, and the Imperial budget for 1898. The editor announces that he will forward to any address Nos. 1 and 2 of this "Russian Journal" gratis, and that no subscription will be received until Aug. 1, 1900. All correspondence should be addressed to the "Editor of the Russian Journal," Millionaia 23, St. Petersburg, Russia.

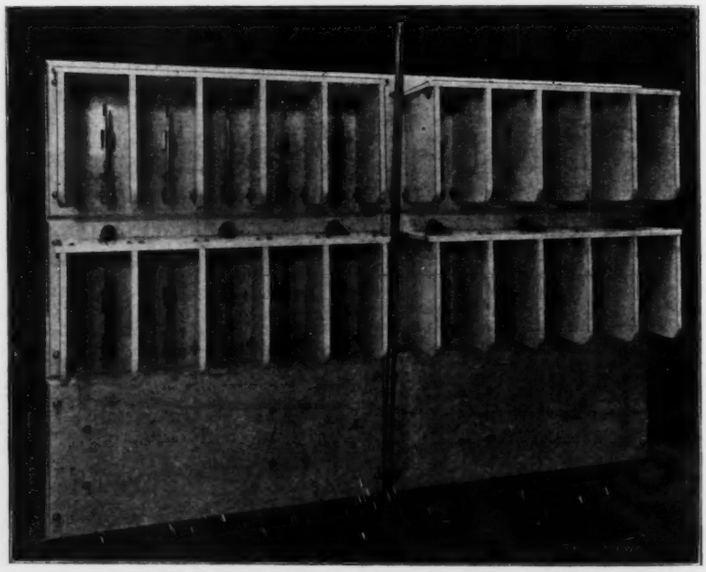


FIG. 3.—SWITCH-BOARD FOR TRANSFORMER.

THE COPPER PRODUCTION OF THE UNITED States, for the year ending Dec. 31, 1899, was 292,105 tons, an increase of 27,934 tons over 1898. Importations of foreign copper in the year amounted to 39,858 tons, an increase of 26,958 tons over the preceding year. The home consumption of copper in 1899 is figured at 162,000 tons, an increase of 18,000 tons over 1898.

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